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No. 231

ENERGY: STATUS AND DEVELOPMENT --V

HONGSHUI RIVER PROJECT

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STATE COUNCIL INSTRUCTION ON DEVELOPING HONGSHUI RIVER

Beijing SHUILI FADIAN [WATER POWER] in Chinese No 4, 12 Apr 82 p 1

["State Council Instruction for Rapid Development of Hongshui River"]

[Text] Developing the rich waterpower resources of Hongshui River is a strategic measure to solve the energy problem of the South China region, and should be included in the Sixth Five-Year Plan and the long-range plan and carried out step by step in a planned way. The development policy is to give first priority to power generation, with consideration for comprehensive utilization such as flood control, shipping, irrigation and aquatic products. In the course of development, the areas and units concerned must start from the overall situation, unite and cooperate, enhance their revolutionary spirit, struggle arduously, organize well, work meticulously, and strive for economy, fast results, good quality and high efficiency, in order to benefit the people.

24 November 1981

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DEVELOPMENT OF THE HYDROELECTRIC POWER BASE OF THE HONGSHUI RIVER

Beijing NENG YUAN [JOURNAL OF ENERGY] No 1, 25 Feb 82, pp 5-7, 14

[Article by Gui Dianwen [2710 3013 2429]: "Speed Up the Development of the Hydraulic Power Base of the Hongshui River"]

[Text] Developing hydropower so as to steadily increase its importance among the primary energy resources constitutes one of China's important energy construction projects. The Hongshui River is one of the important rivers in the southern part of China, with rich hydropower resources. Starting in 1950's, the concerned government departments carried out numerous investigations, surveys and explorations and drafted designs and plans. A large volume of data has thus been accumulated. On this foundation, the Guangxi Hydroelectric Power Planning Committee Office carried out a large volume of work in 1978-79 and compiled the "Hongshui River Consolidated Utilization Plan Report."

The Party Central Committee and the State Council attach much importance to the development of Hongshui River hydraulic power base. In the past 2-5 years, the Ministry of Electric Power Industry, Guizhou Province, the Guangxi Autonomous Region aggressively organized a number of exploration and design units and carried out a large volume of preliminary work in preparation for a basic construction along the main section of Hongshui River and created favorable conditions for speedy development of Hongshui River hydroelectric power base.

1. Urgency of Developing the Hongshui River

The main stream of the Hongshui River is rich in hydropower resources. The total installed capacity is equivalent to approximately 60 percent of the total installed large- and medium-scale hydroelectric power capacity nationwide. Estimating according to China's industrial electricity consumption level today, an industrial production valued at nearly 100 billion yuan can be created annually. An energy resource of such an enormous size, which is inexhaustible, clean, and renewable, is extremely valuable for Guangdong and Guangxi Provinces, which suffer from shortage of electricity and coal.

Guangxi Province is a minority race region. Its economic foundation is relatively fragile today while within its boundaries there are rich reserves of various minerals including tin, aluminum, manganese, titanium, lead, and zinc.

Tin, aluminum, and manganese occupy very important place in our national economy. These resources can be exploited in large quantity if only a large quantity of electricity becomes available. Guangdong is China's special economic region. National economy developed early and rapidly there, but it is being affected by the shortage of electricity. Therefore, speedy development of the Hongshui River hydroelectric power base has sufficiently important practical significance in stimulating the development of the national economy of the South China area.

By developing the Hongshui River, we can not only gain a large quantity of electricity but also reap benefit of flood prevention, navigation, and irrigation.

To build 9-10 step electric stations along the length of the Hongshui River, a population of 180,000 needs to be relocated and 164,000 mu of land must be inundated. This, in comparison with other large-scale hydroelectric stations already built elsewhere in China, is smaller in scale as far as relocation and inundation are concerned. We need only to manage the economic policy properly so that the masses residing in the vicinity of the reservoirs can gain economic benefit from the construction of the electric power stations, there will be no problem that cannot be solved.

The investment made on the hydroelectric power station on each step of the Hongshui River can be completely recovered within 5-7 years after the completion of the construction work. Their economic values are quite evident.

2. Plan for the Development of the Hongshui River

The plan for the Hongshui River development was made on the foundation consisting of a large volume of data and the past experience and lessons. Old ideas of the 1950's, which did not pay attention to the concrete conditions, did not account for inundation loss, and was out of touch with the reality, arbitrarily building tall dams and large reservoirs along the entire section of the river, have been discarded. The irrational way of adopting sweepingly the through-flow type of electric power station, which is difficult to adjust and cannot fully utilize the potential, was not employed either.

The plan for the Hongshui River development was based on the river's resource characteristics and the practical conditions and the guidelines for development were determined: The project puts the emphasis on the electric power generation, but will also take good care of matters related to flood control, navigation, irrigation, and aquatic products. The plan paid careful attention to treat well the relationship between upper and lower reaches, short- and long-range effects, needs and possibilities, engineering benefits and inundation losses.

Concrete plans include the following specifics:

1) Taking into consideration the actual conditions of the entire section of the river, two sites were chosen for the construction of Longtan reservoir and Tianshengqiao reservoir in the upper reaches where the mountains are high

and the gorges are narrow with geographical and geological conditions favorable to the construction of tall dam with relatively small inundation losses and greater potential for adjustment performance for many years to come. River bed type electric power stations suitable for low head and large flow rate were chosen for the mid-section and the lower reaches where the terrain is hilly and plain in order to fully utilize the large volume of water available there. The inundation losses are kept to minimum and the flood releaving capacity increased through adoption of low dam and high lock.

2) A close link between the steps in the upper and lower reaches is maintained as much as possible so as not to lose water head, but to fully utilize the hydropower resources and to facilitate navigation.

3) After the dam sites and the reservoir locations with all the related basic data were gathered, the pivotal position was chosen at a section where the conditions are favorable for separation of water.

4) The combined benefit of flood control, navigation, and irrigation occupied an important part of the planning consideration, although the emphasis was always placed on the power generation. The Hongshui River is a part of the Zhujiang water system. While it must shoulder a portion of the flood control tasks, it should not be overly burdened with the flood prevention tasks.

The development plan which was drafted according to the actual conditions of Hongshui River is, no doubt, a correct plan.

3. Outline of the Project and the Main Hydroelectric Power Stations

During the process of drafting plan for the development of the Hongshui River, nearly 20 steps and dam sites were carefully explored and analyzed, and the number of key steps included in the final plan was reduced to 9 or 10. Namely, Tianshengqiao Bapam, Tianshengqiao Basuo, Pingban (this step will not exist if the normal high water level at Longtan is chosen to be 440 meter), Longtan, Yantan, Dahua, Bailongtan, Etan, Qiaofan, and Datengxia. The major steps among these steps include Longtan, Tianshengqiao, Yantan, Dahua, and Datengxia. The main specifications are as follows.

1) Tianshengqiao step

Tianshengqiao section will be developed in two parts: high dam electric power station and low dam water-drawing type electric power station. When the high dam's normal water level is 780 meters, the low dam normal water level is 645 meters. The combined total installed capacity of the two stations can reach 2.32 million kilowatts and a guaranteed combined output of 1.15 million kilowatts when both stations are operated jointly. Annually, 13.5 billion kW-hr of electricity can be generated. Moreover, the capacity of the high dam is 6.8 billion cubic meters, so not only the reservoir itself has potential for adjustment performance for many years to come, it is also capable of adjusting the flow of water in the downstream steps. This reservoir will displace 25,300 people and inundate 27,200 mu of cultivated land. The Tianshengqiao hydropower station is situated 310 kilometers from Pingguo, 530 kilometers from Liuzhou, 410 kilometers from Nanning, and 1,000 kilometers from Guangzhou.

2) Longtan step

Longtan hydroelectric station is the most important "dragon head" power station in the entire Hongshui River development project and occupies the most important section of the river. Not only do huge economic effect and superior economic index exist in itself, it can also insure the output of the power stations in its downstream to be raised suddenly by a factor of 1.3-2.3.

The center of Longtan is situated at 16 kilometers upstream of Tiane County seat, Guangxi Province. The exposed rocks at the dam site belong mainly to thick calcium sandstone of mid triasic era. The geologists and hydraulics specialists who attended dam site selection meeting in March 1981 concurred in selecting Longtan as the site for the construction of tall dam and large reservoir. When the reservoir normal water level of 400 meters is maintained, the reservoir capacity will be 27.45 billion cubic meters with installed capacity of 4 million kilowatts. When it is operated singly, it has a guaranteed output of 1.53 million kilowatts and an annual output of 18 billion kW-hr of electricity. It can also increase the guaranteed output power to 1.649 million kilowatts obtainable from the power stations located at various steps in its downstream. When the normal water level is 440 meters, the reservoir capacity would be 55 billion cubic meters, and the installed capacity can reach 6 million kilowatts. When it is operated alone, the guaranteed output is 2.28 million kilowatts and the annual electricity output is 23 billion kW-hr. It can also increase the guaranteed output power to 1.905 million kilowatts obtainable from the power stations located at various steps in its downstream.

After the Longtan hydroelectric power station construction work is completed, more than 200 kilometers of navigable river will be created and more than 100 dangerous rapids will be submerged. The navigable waterway in its downstream can also be significantly improved because the regulated flow rate can be increased to 1,100 cubic meters per second.

Longtan reservoir will have an important impact on the flood control of the regions in its downstream. The Hongshui River carries a relatively large quantity of sand. However, utilizing the dead capacity of the Longtan reservoir (approximately 10 billion cubic meters), sand that can be carried in over 300 years from upstream can be stored in it, thus winning sufficient time in which to carry out water and soil conservation work upstream.

Longtan hydroelectric power station is situated 210 kilometers from Pingguo, 270 kilometers from Liuzhou, 319 kilometers from Nanning, and 800 kilometers from Guangzhou.

As described above, a comparison of the two alternative plans for Longtan hydroelectric station, e.g., a 440-meter-and a 400-meter-water level, indicates a difference in installed capacity of 2 million kilowatts, a difference in guaranteed power output of 1 million kilowatts, and a difference in annual electricity generation of 5 billion kW-hr. Which is equivalent of building an extra thermoelectric power plant with a 1 million-kilowatt capacity. As to the inundation losses, the 400-meter plan would displace 64,000 persons and inundate 55,000 mu of cultivated land, while the 440-meter plan would displace

99,000 people and inundate 94,700 mu of cultivated land. The differences are 35,000 people and 39,700 mu. To be able to gain the huge economic benefit in exchange for relocating 35,000 people and inundating 39,700 mu of cultivated land is obviously profitable. However, taking into consideration the scarcity of cultivated land and the difficulty of relocating people in the mountainous region, we recommend that the project be carried out in installments, including investment, construction, relocation, and power generation. At the same time, the economic benefit reaped from early stage power generation may be used to solve the investment problem of the later stage construction work. Moreover, a portion of the relocation work may be postponed and carried out a few years later.

3) Yantan hydroelectric power station

Yantan is situated at the boundary of Bama County, Guangxi Province. It is located at a central location and is one of the key power stations of Hongshui River project linking the upstream and the downstream. The dam site was chosen at a section with favorable geological conditions. Its normal water level is 223 meters, effective reservoir capacity is 1.29 billion cubic meters with installed capacity of 1.4 million kilowatts. When it is operating alone, the guaranteed output is 231,000 kilowatts with an annual electricity output of 5.97 billion kW-hr. If it is operated in conjunction with the power stations in its upstream such as Longtan station, its guaranteed output can be increased to 768,000 kilowatts with an annual electricity output increased to 8 billion kW-hr. It can also act as the antiadjustment reservoir for the Longtan power station, making the Longtan hydroelectric power station to shoulder a huge peak load of the electric power system. The reservoir would displace 37,600 people and inundate 29,200 mu of cultivated land. If the reservoir level is lowered to 219 meters during the flood season, it can guarantee for 20 years that the Bama County seat will not be flooded. Yantan power station is situated 90 kilometers from Pingguo, 200 kilometers from Nanning, 220 kilometers from Liuzhou, and 720 kilometers from Guangzhou.

4) Dahua hydroelectric power station

Dahua hydroelectric powerstation is a large-scale electric power station on Hongshui River which is under construction. It is situated 84 kilometers downstream of Yantan. The first stage installed capacity is 400,000 kilowatts, with guaranteed output of 105,000 kilowatts and annual electricity output of 2.06 billion kW-hr. The first unit is expected to be put into operation in 1983, and the entire construction work is expected to be finished by 1985. Its output can be expanded to 600,000 kilowatts, with guaranteed output power of 159,000 kilowatts and annual electricity output increased to 3.6 billion kW-hr after the construction work of the electric power stations in its upstream reaches such as Longtan station is completed.

5) Datengxia hydroelectric power station

Datengxia hydroelectric power station is the last important step of that section of river included in this project. Its center is located at the mouth of Datengxia, 12 kilometers north of Guiping County, Guangxi Province. It controls a total rain gathering area of 190,400 square kilometers. Since Datengxia passes through the Kuizhong basin, the inundation losses must be considered very carefully.

When its normal reservoir water level is 57 meters, the reservoir capacity is 2.1 billion cubic meters, with an installed capacity of 1.2 million kilowatts. When it is operating alone, the guaranteed output is 208,000 kilowatts with an annual electricity output of 5.39 billion kW-hr. When it is operating in conjunction with the electric power stations in its upstream such as Longtan station, its guaranteed output can be increased to 450,000 kilowatts with an annual electricity output of 6.65 billion kW-hr. During the flood season when the water level is controlled and kept at 53 meters, the displaced population would be 47,700 people and the inundated cultivated land would be 25,900 mu. Datengxia power station is located 120 kilometers from Liuzhou and 400 kilometers from Guangzhou.

4. Other Overall Benefits

1) Flood control

Based on the statistical data concerning historical flood damages along the banks of the Hongshui River, Qingjiang, and Xunjiang, and the flood control situation today, and using a standard of one flood per 20 years, the Hongshui River project is economically feasible and also satisfies the needs for flood control. The plan has incorporated into Longtan and Datengxia reservoirs a fixed amount of flood control reservoir capacity margin, so that once in 50 years flood peak flow rate can be reduced to a level below that of once in 20 years flood level.

2) Navigation

After the Longtan reservoir construction work is finished and the waterway widened, it can serve as a good navigation trunk line. Coal of Guizhou Province and phosphate ore of both Yunnan and Guizhou provinces may be transported via the waterway to Guangdong and Guangxi provinces.

3) Irrigation

Based on the 1977 statistics, there are a farming population of 4,361,500 people in the Hongshui River basin with 5,915,900 mu of cultivated land including 2,269,300 mu of paddy field. Demand for irrigation over expanded area is expected as agriculture expands further.

The plan has considered irrigation problems in the three regions--upstream, left bank, and right bank. The goal of the plan is to achieve, by the year 2,000, at least 1 mu of paddy field per person and paddy field occupying 80 percent or so of total cultivated land. The plan was made according to the actual situations of the area after carefully analyzing the population and cultivated land growth situations. The upstream region consists mainly of mountainous area formed from limestone lava and cultivated lands are scattered.

This region is rich in underground water, so the irrigation of the region is to be done mainly by fully utilizing the flow through water and the underground water, utilizing the scattered small-scale field hydraulic engineering project. Irrigation of both banks in the middle and downstream regions involves large area, so electrically powered water pumps are to be used for the irrigation purposes. Water will be pumped from the Hongshui River into existing medium- and small-scale reservoirs from which to be distributed to the f'eld. The main goal is to transform all existing fields into paddy fields and to convert all existing dry land into irrigated land, thus increasing the total irrigated area to 1.45 million mu.

Wuxuan irrigation district on both banks of Qingjiang contains approximately [illegible] mu of cultivated land, and in Guiping and Pingnan Counties in the downstream of Datengxia are 365,000 mu of cultivated land. The irrigation plan for these areas will be formulated after further study.

Other miscellaneous items such as aquatic life culture in the reservoirs, environmental protection, and travel attraction will be considered further in conjunction with the feasibility study of each engineering project.

3. Some Suggestions Concerning Short Range Construction Work

On matters related to the selection of short range construction work and the order in which the electric power stations at various steps of Hongshui River are to be developed, I would like to make the following suggestions.

Tianshengqiao low dam: Preliminary design and preparation for construction of its hydroelectric power station have been completed. This project ought to be reactivated as soon as possible so that it may be finished early and engaged in power generation.

Yantan electric power station is situated in a central location and is nearest to the Pingguo aluminum base. After its construction work is finished, not only its immediate vicinity will be greatly benefited by it, the Dahua and Etan power stations in its downstream will also be benefited by it in the form of increased output of 57,000 kilowatts. Moreover, its preliminary work was started quite early and its preliminary design can be finished by 1982. I recommend that preparation for its construction work be started as soon as the Tianshengqiao low dam's construction work is resumed.

Longtan hydroelectric station is the most important station among all the power stations at various steps of the Hongshui River. In view of its huge scale and large investment, and the fact that the exploration and design works have not yet been completed, it cannot be developed as a first stage engineering project. However, when the first stage construction work of the other stations is decided, the preliminary work related to Longtan hydroelectric power station must be continuously carried out simultaneously so as to facilitate early development of the Longtan hydroelectric power station. We must strive to finish construction of Longtan hydroelectric power station by the end of this century. It is quite possible to acquire 10 million kilowatt of electric power from the Hongshui River.

The concerned governmental departments have met recently to review the Hongshui River project, and consensus of opinion was reached concerning the development policy, the step development policy, and short-range development procedure of the Hongshui River. The Hongshui River is rich in hydropower resources, with superior technical and economic indexes. A large volume of preliminary capital construction work has been done, and the project has all the necessary basic conditions for a speedy development. I would like to recommend that the concerned governmental departments work in cooperation with the local region in order to speed up the progress of the Hongshui River development project, so the rich hydroelectric resources of the Hongshui River may be able to serve the four modernizations as soon as possible.

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THE STEP HYDROELECTRIC STATION OF THE HONGSHUI RIVER

Beijing NENG YUAN [JOURNAL OF ENERGY] No 1, 25 Feb 82 pp 12-14

[Article by Jiang Ying [3068 5391]: "An important Energy Base in China--The Step Hydroelectric Station of the Hongshui River"]

[Excerpts] In early October 1981, the State Energy Commission and the State Planning Commission met in Beijing to review the Hongshui River development project. Altogether 75 persons, including party committee members from the concerned provinces, regions and ministry and a number of specialists and professors, participated in the review. It was the unanimous opinion of those who participated that the Hongshui River is a "rich mine" of hydroelectric power and is one of the important energy bases in China. The Hongshui River is situated in the South China area where there is acute shortage of energy. Therefore, developing the Hongshui River to provide electricity to Guangdong, Guangxi, and Guizhou provinces has sufficiently important practical significance. Those who participated in the review recommended unanimously that the hydroelectric resources of Hongshui River should be developed as soon as possible.

Superior Natural Conditions Cultivated Rich Hydropower Resources

Hongshui River is the main stream of the Xijiang water system in the Zhujiang river basin. It originates in the plateau of Yunnan and Guizhou provinces. It is called Nanpanjiang in the upstream and flows from Yunnan to Guizhou where it joins with Beipanjiang and becomes the Hongshui. Hongshui River flows along the border between Guizhou and Guangxi provinces, entering Guangxi at Tiane County, crossing the midsection of Guangxi and joins Liujiang at Sanjiangkou, Shilongzhen, Xiangzhou County. From there on, the river is called Qinjiang. The Hongshui River got its name through the reddish brown color of its water, because it flows past red-colored rock layers.

The scope of the Hongshui River project study went beyond the geographic range of the Hongshui River. It was extended in the upstream to the mouth of Huanqinhe on Nanpanjiang, and in the downstream to the mouth of Datengxia on Qinjiang. Therefore, the Hongshui River referred to in this article includes this expanded range of the Hongshui River. The total length of the section of river under study is 1,050 kilometers with an area of 190,000 square kilometers of river basin. The Hongshui River is characterized by the large volume of water, steep slope, and concentrated drop. Therefore, the river is sufficiently rich in the hydropower resources.

The first important feature of the Hongshui River is the large volume of water. Because it is situated in the subtropical climate zone, the climate is mild with plentiful rain. The annual precipitation in Yunnan and Guizhou in the upper reaches of the river is 1,200 millimeters. The precipitation inside the border of Guangxi is even greater--1,500-1,800 millimeters. At the mouth of Datengxia through which the main stream discharges, the average flow rate taken over many years reaches 4,200 cubic meters per second, with a total annual flow rate of as much as 133 billion cubic meters. Maximum flow rate of as much as 45,700 cubic meters per second has actually been recorded. If these figures are compared with those of the Huanghe, the second largest river in China, its river basin is only 1/4 that of the Huanghe, but its water is 3 times that of Huanghe in volume and its maximum flow rate of more than 4 times that of Huanghe has been recorded.

The second important feature of the Hongshui River is the concentrated drop. Because it is situated in the region of transition from the plateau of Yunnan and Guizhou to the Zhujiang delta, it drops from an elevation of approximately 780 meter at the mouth of Huangnihe to an elevation of 23.5 meter at the Datengxia dam site during dry season. The total head drop over the section of river under project consideration amounts to more than 750 meters. There are several sections of the river where the drops are especially concentrated. On a section of Nanpanjiang at Nagong from Tianshengqiao, a drop of 181 meters is concentrated in a section of river of only 14.5 kilometers in length, with an average drop of 12-13 meters per kilometer. This section of the river has the highest concentration of drops. Between the spot where Nanpanjiang and Beipanjiang meet and Tiane, the Hongshui River flows past high mountains and narrow gorges with many rapids and few population. This is a site which is highly suitable for the development of hydroelectric power station. Between Tiane and the mouth of Fongfangxiagu, the river continues to thread through the mountain valley, with very little open and flat land on either bank. The inundation losses will be small if a hydroelectric power station is built here. Downstream of Fongfangxiagu, the river flows over hills and plains with flat river bed and well developed sand dunes. Both banks of the river consist of flat and open land with high concentration of cultivated land. Further downstream, from Lema to the mouth of Datengxia, the river threads through the famous Datengxiagu, 44 kilometers in length. Both banks of the river consist of high mountains and steep slopes, with a few population and very beautiful scenery. Because of its geographical conditions, the high dam and large reservoir sites chosen by the plan are concentrated in the mountainous area near the border between Guizhou and Guangxi, where the land is small and population is few. Medium and low water head steps with relatively small reservoirs are distributed over the mid-section and the downstream regions in order to fully utilize the energy of the Hongshui River water. The inundation losses due to these reservoirs are much smaller compared with other large-scale hydroelectric power stations already built elsewhere in China. A hydropower resource so rich and so superior, there are very few of the like of it in China.

After Surveying Seven Times the Ribbon Was Cut; The Plan Was Drafted on the Foundation of a Summary of Past Lessons

During the process of reviewing the Hongshui River project, the 10-step development plan submitted by the Guangxi Hydroelectric Planning Committee Office was praised unanimously by those who participated in the review process as a rational and correct project plan.

The Hongshui River project has undergone four revisions already. This plan was formulated on the foundation of the experiences and lessons learned from the past three undertakings. The first two were the plans drafted in 1959 and 1960. Under the direction of a guideline which excessively emphasized storage as a means of treatment, large reservoirs were distributed along the length of the river without paying much attention to the concrete conditions and without counting the inundation losses. Thus, there were only 6-7 steps over the entire section of the river, and based on the population and the land statistics of that time, 400,000 people were to be relocated and 600,000-700,000 mu of cultivated land were to be inundated. This was obviously irrational. The third plan was made in 1972. This plan was overly in favor of medium and low head through flow type of hydroelectric power stations, and a total of 12 steps were distributed over the length of the river. This way, the inundation loss of cultivated land was only 80,000 mu and the displaced population was only 70,000. However, this plan neglected the necessary adjustment reservoir; it neglected rational utilization of the hydropower resources and the demand for consolidated utilization. As a result, the total installed capacity and the total annual electricity generation of the step electric power stations were less than one-half that of the most recent plan, and there was basically no flood control benefit to talk about. Therefore, this plan was deemed unsatisfactory either.

To be sure, these three plans did have their positive contributions also. For example, through repeated planning and large volume of exploratory work, dam sites such as Longtan, Yantan, and Datengxia have been selected, and the 1972 plan has laid down the foundation for design and development of Dahua hydroelectric power station. Formulation of the recent 1980 plan and its 10-step development project has taken advantage of the past experiences and lessons. This plan has treated the relationship between upstream and downstream, short-range and long-range, needs and possibilities, as well as engineering benefits and inundaton losses more equitably.

What Experiences and Lessons Have We Learned From the Four Plans of the Hongshui River

1) In formulating stream project, one must start out from the natural conditions of the stream and the economic situations of the region and determine the correct guidelines and tasks to be accomplished by the project. The recent plan has clearly defined the guidelines for the development of the Hongshui River. Namely, the emphasis is on the electric power generation with appropriate consideration for the flood control, navigation, irrigation, and aquatic products. The past experiences and lessons have laid down good foundation for rational selection of the development plan.

2) Any stream project must take into consideration China's national situations characterized by a large population and small cultivated land. The stream development project must be made in such a way to minimize the inundation losses, to achieve rational and economic utilization of hydropower resources, and to maximize the economic return through realizing consolidated utilization

of the energy resources. We must not inundate too much land and displace too many people in pursuit of unrealistically high goal for consolidated utilization of hydropower resources, nor should we disregard rational utilization of hydropower resources just so as to reduce the size of inundated land area and adopt sweepingly the low dam through flow type of power generation format.

3) Distribution of steps as part of the stream development plan must take into consideration the guidelines, tasks, and the goals of consolidated utilization. Several alternative plans should be formulated and their overall technical and economic merits compared, so as to be able to select a plan which best matches the needs of local national economy.

4) A stream step development plan with an emphasis on the electric power generation should consider large-scale reservoirs having good adjustment capability at appropriate sites in the upper and mid-section of the river so that the natural flow may be regulated by these reservoirs and the benefit of hydropower resources may be maximized. If the plan is formulated according to this rule, not only the inundation losses may be reduced but the regulating effect of the reservoirs can also be fully utilized and the efficiency and benefit of electric power generation at each step along the river may be increased. For example, it is far superior to build Tianshengqiao high dam and Longtan large-scale reservoir in the mountainous regions where the inundation losses will be smaller than to build large reservoirs in the hilly and plain regions in the downstream.

5) The quality of stream planning work is closely related to the depth to which the exploratory design work was carried out and also to the degree of understanding the planning personnel had about the local economic situations. The Hongshui River and its tributaries have been extensively explored and studied over the past 2 decades, and the preliminary design work of a number of key steps was carried out in recent year, which laid down firm foundation for the success of this project.

Stream planning is not finished in one big step, it is a process of continuous practice and continous revision. A stream planning must undergo many revisions. It is a process of approaching the practicality and perfection step by step.

The plan that was formulated this time was very superior. A total of 10 step power stations from Tianshengqiao to Datengxia has a total installed capacity of 11 million kilowatts and an annual electricity generation capacity of 60 billion kW-hr. It is comparable with the hydroelectric base in the upper reaches of Huanghe, which is commonly recognized as China's hydroelectric "rich mine" among all big rivers where the development conditions are favorable and development of hydropower resources has been carried out extensively. In the upper reaches of Huanghe, between Longyangxia and Qintongxia, there are 16 step power stations with a total installed capacity of more than 12 million kilowatts and an annual electricity generation of 49 billion kW-hr. The total installed capacities of these two rivers and their total investments are not much different, but the annual electricity generation at the Hongshui River is 20 percent greater and its inundation losses are [illegible] less than those of

Huanghe. Moreover, the power stations on the Hongshui River are closer to the electricity consuming centers. Therefore, the Hongshui River and Huanghe are the two "richest mines" of hydropower resources where the development potentials are the greatest among China's numerous rivers where the hydropower resources are rich.

Of the ten step electric power stations of the Hongshui River, in addition to Dahua hydroelectric station (first stage capacity of 400,000 kilowatts; final capacity of 600,000 kilowatts) whose construction work has already begun, the following five main step electric power stations have had rather extensive exploratory and design work performed so far and their design drafts are more specific. These five stations are Tianshengqiao high dam (1.08 million kilowatts), Tianshengqiao low dam (1.24 million kilowatts), Longtan (4-6 million kilowatts), Yantan (1.4 million kilowatts), and Datengxia (1.2 million kilowatts). These six key hydroelectric stations are considered definitely feasible. The total installed capacity of these six power stations reaches as much as 10 million kilowatts with an annual electricity generation of 50 billion kW-hr. After they are all completely developed and utilized, approximately 30 million tons of raw coal used for the purpose of electric power generation can be saved annually. The other four step electric power stations are Pingban (360,000 kilowatts), Bailongtan (180,000 kilowatts), Etan (first stage construction of 60,000 kilowatt capacity has been finished; an additional 96,000 kilowatt capacity will be built later) and Qiaofan (500,000 kilowatts). Exploratory and design works of these stations have not yet been done extensively. So the review committee recommended that additional planning and proofing be made; adjustments and changes may also be made if necessary.

Aggressively Carrying Out the Preliminary Work Well, in Order To Speed Up the Process of the Hongshui River Development

The review committee studied the problems related to the development procedure of the Hongshui River in minuate detail. The members of committee were unanimous in opinion that Tianshengqiao high dam and low dam ought to be treated as a set of electric power stations and constructed as a group. These two stations and the Yantan electric power stations are medium in scope and thus compatible with China's strength and needs today. The technology is also relatively simple, with relatively small inundation losses, relatively small displaced population, and significantly beneficial effect. They have the potential of being constructed in the near future. These plans should be included as part of the national plans and the construction work started as soon as possible. The review committee further recognized that the Longtan hydroelectric power station is a key construction project of the Hongshui River. It is the "dragon head" of the entire river. It is expected to have significant impact on the electric power generation as well as on the flood control, navigation, and transportation. However, the scope of Longtan hydroelectric power station is enormous. It requires large investment, long construction period, and complicated technology. Therefore, this project should be carried out only after the three stations referred to above are finished. In the meantime, further preliminary work, scientific experiment, and research work should be carried out. The Datengxia project has multiple utilization objectives. It occupies an important geographical position and, after it is developed, the effect and benefit from its general utilization are expected to be very significant. There exist different views today concerning how the relationship between electric power generation, flood control, and navigation should be treated. This subject must be investigated and studied further and negotiated repeatedly. As soon as the preparatory work matures and the national strength is capable of undertaking the construction work, Longtan and Datengxia hydroelectric station projects should be started as soon as possible.

Today, the Hongshui River development project has the necessary conditions for speedy completion. The first stage construction work of Etan hydroelectric power station has been completed and it is generating 60,000 kilowatts, while the first unit of the Dahua hydroelectric power station is expected to be in operation by 1983. The Tianshengqiao low dam is a hydroelectric power station which utilizes most highly concentrated drop. Its preliminary design was completed in 1978, and the first stage construction work for 800,000-kilowatt capacity has all the necessary conditions to get under way. Today, exploration and design work of the four key hydroelectric power stations at Tianshengqiao high dam, Longtan, Yantan, and Datengxia are being carried out. The preliminary design of Yantan hydroelectric power station is expected to be finished by around 1985. This is one of China's hydroelectric bases in which the largest amount of exploratory and design efforts is spent today.

Many constructive opinions were presented through the conference. For example, various ways of raising fund for the hydroelectric power base construction so as to speed up development of the Hongshui River hydroelectric power base; emphasis on the importance of solving the relocation problem well and the need for a well-developed relocation plan; emphasis on the importance of preliminary work, the importance of technical and economic proof, and the importance of comparing many alternative plans; the construction work period should be shortened as much as possible so as to increase the economic effect of the investment and to increase the recovery rate; and that economic policy beneficial to speedy development of hydroelectric power be enacted so as to rationally distribute the economic profit and to mobilize the initiative of the regions with rich hydroelectric power resources to develop them more aggressively.

The Hongshui River review committee was not only able to reach a basically unanimous opinion on such main topics as the development policy of the Hongshui River, the development plan of steps, and the short-range development procedure; but also able to produce many useful recommendations concerning the work of the next stage, and thus laid down good foundation for the speedy development of the Hongshui River hydroelectric power.

9113
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POWER GENERATION, COMPREHENSIVE USE OF HONGSHUI RIVER

Beijing SHUILI FADIAN [WATER POWER] in Chinese No 4, 12 Apr 82 pp 1-4

[Speech by Vice Chairman Yang Bo [2799 3134], State Energy Commission, at the Meeting to Examine the Hongshui River Development Plan: "Implementing the Policy of First Priority on Power Generation and Comprehensive Utilization in Developing Hongshui River (Excerpts)"]

[Text] The meeting to examine the Hongshui River plan is an important one in the development of China's waterpower resources. During the meeting, Vice Premier Yu Qiuli [0151 4428 6849] gave an important talk, and Vice Chairman Gan Ku [3927 5388] of the Guangxi Zhuang Autonomous Region people's government made a report and explanations on the Hongshui River plan. With the overall situation in mind, a conscientious responsible spirit and a practical and realistic attitude, the comrades attending the meeting discussed the "planning report" relatively fully and expressed many good opinions. Besides group discussions, responsible comrades of Guizhou and Guangdong provinces and of the Ministries of Water Conservation and Power and 13 representatives of various fields, experts and professors made statements at the meeting. Several comrades made written statements. By means of discussions and deliberations, all attendees arrived at basically unanimous views on the Hongshui River development policy, the cascade development project and the short-term development program, and made many useful suggestions on the next step of the work. With the joint effort of the attendees, one may say that the meeting has been a good one, reaping the result of developing democracy and pooling the collective wisdom and achieving the expected goal. Now, based on the views expressed at the deliberations and the discussions of the small leading groups, I will concentrate on four issues in my talk.

I. The Hongshui River Development Policy

After discussions at the meeting, all agreed that power generation should be given first priority, with consideration for comprehensive utilization such as flood control, shipping, irrigation and aquatic products.

The Hongshui River valley plan under discussion stretches over a length of 1,050 km, from Nanpanjiang River's Tianshengqiao in the upper reaches to Qianjiang River's Datengxia in the lower reaches, and traverses Guizhou and Guangxi. With abundant waterpower resources, an annual average flow of 130 billion cubic meters and a drop of 760 meters, the river is a "rich mine" among China's waterpower resources. After the completion of the development, we will have around 10 million kilowatt of installed hydroelectric capacity, with an annual average power generation of 50 to 60 billion kilowatt-hour, and the river will become an important energy base in China. Hongshui River is located in the South China region where there is a shortage of energy. Its development and construction will effectively promote the economic development of Guangdong, Guangxi and Guizhou, and possess an extremely important practical significance in solving the serious power shortage of Guangdong and Guangxi at present and for a time to come. Therefore, giving first priority to power generation is the correct policy.

Hongshui River is the mainstream of the Xijiang River system in the Pearl River valley. The two shores of Xunjiang River and the delta region of Xibeijiang River in the lower reaches are relatively developed where the population is fairly dense and the agricultural production is of a relatively high level, and where large and medium cities with concentrated industries such as Guangzhou, Wuzhou and Fushan are located. Therefore, in the course of developing Hongshui River, we must give consideration to flood control in the lower reaches in order to reap the benefit of comprehensive utilization. We find that "giving first place to draining and considering both draining and storing," the flood control policy advanced by the Pearl River Water Conservation Commission of the Ministry of Water Conservation, correct. Thus, when planning and designing the main reservoirs of Hongshui River, we must reserve a certain amount of flood control reservoir capacity in connection with the Pearl River flood control plan. As for the size of such reserve capacity, especially that of Datengxia, there were different views at this meeting, calling for further exploration and demonstration. The development policy of Qiangjiang River section proposed by the comrades of the Ministry of Water Conservation is to "give equal attention to flood control, power generation and shipping, with consideration for others." We hope that, after this meeting, the Ministries of Water Conservation and Power and the provinces and region concerned will, in line with the principle of rational and suitable improvement of flood control standard and the demand to reduce inundation and population relocation to the minimum, start from the practical conditions, give suitable consideration to the upper, middle and lower reaches, make further investigations and studies and repeated consultations and discussions, and propose a feasible concrete plan relatively satisfactory to all sides for examination and approval by the superior department concerned.

In developing Hongshui River, especially its lower reaches, we must also consider the development of shipping. It is not only linked with the issue of how to develop to the maximum possible the comprehensive benefits of the river, but also has a great significance in promoting the inland river shipping of the South China region. At this meeting, the comrades of the Ministry of Communication made several requests, but whether they are feasible and whether there are sufficient grounds were not fully discussed. For this reason, we hope that the Ministry of Communication will make further investigations and studies based on the different conditions of Hongshui and Qianjiang Rivers, exchange views with the provinces, region and units concerned, proceed with conscientious technical and economic proofs and prepare a feasibility report for examination and approval by the department concerned of the state.

The issues on aquatic products breeding, log floating over dams, environmental protection and ecological balance were not discussed at this meeting. We hope that they will be given attention in future planning and engineering designing, and that rational arrangements will be made and suitable plans of solution and concrete measures proposed.

II. The Cascade Development Project of Hongshui River

After discussion, all attendees basically agreed with the 10-cascade development plan proposed in the "Report on the Comprehensive Utilization Plan of Hongshui River" submitted by the people's government of the Guangxi Zhuang Autonomous Region. The six key cascades of a control nature, i.e., Bapan and Basuo* of Tianshengqiao, Longtan, Yantan, Dahua and Datengxia, were affirmed. The remaining cascade power stations require further investigation and study, supplemental planning and demonstration, to be readjusted and revised if necessary.

Here, I wish to discuss the planning of Longtan and Datengxia, the two key cascades, mainly the issue of the power generating water level.

The "treasure of treasures" in the "rich mine" of Hongshui River, Longtan is the "heart" of the entire river valley. On this point, the views were unanimous. Building the Longtan hydroelectric station, whether in terms of power generation or in terms of flood control and shipping, is particularly important and constitutes indeed the key project of the first importance in the entire river valley. Upon completion, its benefits will far surpass those of other cascades. However, in view of its gigantic scale, large investment, the time required and the technological complexities, and the fact that it involves relocating a considerable portion of minority inhabitants in Guizhou and Guangxi, the views of those concerned at the meeting were not unanimous, and the project requires further study and consultation. No immediate decision is necessary. Nevertheless, to facilitate the work of the next stage, we may first determine the power generating water level. Our view is to set it tentatively at 400 meters and to study and explore the feasibility of developing it by stages. We must also proceed earnestly with experiments and demonstrations on relevant scientific and technical problems.

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*High and low dams, respectively.

A multigoal comprehensive utilization project, Datengxia occupies an important geographic position. The benefits of comprehensive utilization upon its completion are obvious. At present, there are still different views on how to properly handle the relations among power generation, flood control and shipping, and further investigations and studies and demonstrations are required. We hope that the units, provinces and region concerned will strengthen their cooperation, make repeated consultations and arrive at a unanimous view as soon as possible. To facilitate the work of the next stage, we may tentatively set the power generation water level at 57 meters. As for the suitable flood control reservoir capacity and the integration of flood control and power generation capacities, they may be demonstrated and deliberated during designing for examination and approval by the superior department in charge.

III. The Development Order of the Cascades

The starting point in considering this issue should be based on the natural conditions of Hongshui River, the power consumption need, the feasibility of the national strength, the investment benefit and the depth of preparatory work. By weighing and comparing such factors, we will select the best plan for early development. Judging from the current conditions, we envisage the following concrete stages of development.

1. For the Tianshengqiao low dam (Basuo), work will resume in 1982.

2. For the Tianshengqiao high dam (Bapan) and Yantan hydroelectric stations, we must earnestly perform the preparatory work, propose a preliminary plan as soon as possible and strive to start work in the Sixth Five-Year Plan. Just which of the two projects should start first, whether the constructions of Bapan and Basuo can be staggered, and what year construction should start will be determined in state planning.

3. The preparatory work on the Longtan and Datengxia hydroelectric stations must be earnestly performed. As long as the preparatory work is completed and the preliminary plan approved, concrete decisions on the time to start construction will be decided in state planning.

When considering the order of development and arranging the engineering projects, we must conscientiously treat and carefully handle the issue of relocating the inhabitants, especially when minorities are involved. In the preliminary planning of the relevant engineering projects, we must prepare appropriate and feasible plans on relocation. In practical work, while properly performing the political-ideological work on the masses, the areas and units concerned must protect the economic interests of the people and make sure that the income of those relocated is not reduced from the original level. Where possible, their living should be somewhat improved.

In regard to the development of the 10 cascades of Hongshui River and the arrangement of the time limits, the comrades of the Water and Power

General Bureau of the Ministry of Power presented a preliminary conception in their statements. During the discussions, many comrades found it rather too slow, and suggested a more positive approach, striving to complete the development within this century, viz., before the year 2000. I find that this aspiration is good and that we should aim at this goal. As for the time limits for the various projects, especially those which can be launched in the near future, I agree with the view of many experts that we should make further conscientious and careful studies during planning and shorten the time limits as much as possible under the condition of guaranteeing the quality. The Ministry of Power is requested to give full attention to this issue. In the future, we must never fight another attrition war or permit the occurrence of "huzi" engineering. Shortening the time limit and seeking an early recovery of the investment constitute an issue linked with the rapid development of investment benefits and the progress of the "four modernizations" of our state. We must handle it solemnly and solve it realistically.

IV. Several Points on the Work hereafter

1. The report on the Hongshui River plan deliberated at this meeting was proposed on the basis of the tremendous amount of arduous work performed by the broad cadres, engineering and technical personnel and worker comrades of the areas, departments and survey and design units concerned. It is a relatively good and basically feasible plan which won the praises of the attendees and their agreement in principle. However, one should say that it is not, nor is it possible to be, perfect or problem free. Precisely as pointed out by some comrades, some problems were not brought up; some were not given thorough consideration; different views still existed on others in spite of the repeated consultations. In other words, the entire planning work has not concluded. Thus, we must, in our work hereafter, continue to investigate and study and to analyze and compare, continue to heed the opinions of all sides, further intensify our understanding of the laws of nature in practice, and make constant revisions and adjustments to the current plan. With the Marxist dialectic materialist epistemology of "practice, understanding, practice again and understanding again" developed by Comrade Mao Zedong, we must continue to perfect the Hongshui River plan.

A multibenefit river, Hongshui River calls for comprehensive utilization. In his talk, Comrade Yu Qiuli asked us to have an overall view in planning work and to consider issues from the macroscopic angle, instead of handling them in terms of one area, one industry or one department. It is extremely important, and we should follow it thoroughly in work. In regard to comprehensive utilization and overall development, we must consider the feasibility as well as the need, the future as well as the reality, and the key point as well as all sides and, planting our feet on solid ground and starting from the practical, properly handle the relations among all sides. We must not, in disregard of the national conditions and national strength, go all out and set a high goal, tackle all sides and undertake anything and everything. If so, we will be spending more time, dispersing our strengths and affecting the progress of Hongshui River development.

4. Preparatory work must be fully and properly performed for the engineering work of each cascade, including immediate and future developments. Particularly in regard to geology, hydrology and dam site and dam type selections and in regard to investment results, we must make full economic and technical demonstrations, propose many plans for comparison, select the best among them and prepare feasibility reports. We must not take hasty actions or start in a hurry. In this respect, our lessons in the past were many and very profound. We must properly summarize and conscientiously assimilate them. For a long time, there has been a common defect in our planning and discussion: We strive for the number of projects and the amount of investment, at times even squabbling fiercely over them, yet we do not give adequate consideration to the preparatory work of the projects, their feasibility in science and technology, and the advisability of the investment, and have no or insufficient grounds. As a result, when the projects are acquired and determined and the construction started, either the engineering geology runs into problems, or the hydrology and the water quality are incompatible with the requirements, either the construction budget has to be increased again and again, or the investment result is very poor, even to the extent of doing the work over again and creating a great waste. This situation must never happen again in the future.

In the course of developing Hongshui River, regardless of what project, before the completion of preparatory work, before full economic and technical demonstrations, and before a feasibility study report, no matter how important the project and how obvious the benefits, it must not be included in the plan. After the completion of preparatory work, the approval of the preliminary design and the arrangement of the plan, we must truly concentrate our strengths to fight a battle of annihilation. Whether in the allocation of investment, the supply of material and equipment or the assignment of construction forces, we must earnestly guarantee it according to the progress of construction, strengthen management, organize rationally, perform the work painstakingly, stress business accounting and assure the engineering quality in the course of construction and, in accordance with the determined time limit, press on to the finish without letup, so that the limited investment of the state will develop its economic benefits as soon as possible.

5. As the many advantages of developing hydroelectricity are recognized by everyone, we must take a positive attitude. However, it also has its natural drawbacks, i.e., the problem of high and low water flow and that of installed capacity and assurance of power supply. Therefore, while planning the construction of the Hongshui River hydroelectric stations, we must coordinate them with the necessary and commensurate construction of thermoelectric stations. The power supply area of the Hongshui River hydroelectric stations is Guangdong, Guangxi and Guizhou, mainly the first two. Thus, while planning the construction of power stations, we

must plan for the construction of appropriate substations. In regard to the location of thermoelectric stations, system planning and power transmission lines, the Ministry of Power must earnestly study them, proceed promptly with technical and economic comparisons and prepare reports on planning and designing.

4. In regard to organization and leadership, fund raising and the relevant issues of economic policy of Hongshui River development, the attendees made some good suggestions, but there was no time for detailed discussions. We hope that, after the meeting, the two provinces and the region, the departments concerned and the experts will form concrete opinions and submit them to the State Planning, State Agricultural and State Energy Commissions, and we will study them again and present them to the State Council for examination and approval.

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COMMENTS BY SPECIALISTS OF ORGANIZATIONS CONCERNED WITH PLANNING HONGSHUI PROJECT

Beijing SHUILI FADIAN [WATER POWER] in Chinese No 4, 12 Apr 82 pp 5-9

[Abstract from HONGSHUIHE GUIHUA SHENCHA HUIYI ZILIAO (MATERIALS OF HONGSHUI PROJECT PLANNING AND INVESTIGATION CONFERENCE)]

[Text] Li Eding [2621 501 7844] (formerly Deputy Minister of Ministry of Electrical Power Industry): A great deal of surveying, planning, and designing work has been carried out concerning the Hongshui project since the 1950's and the Planning Report has been officially completed by Guangxi Autonomous Region. Just as everyone has pointed out during the discussion, conditions are now complete for its development. Central party leaders, the National Planning Committee, and the National Energy Resources Committee have always been very concerned with the project. When Comrade Zi Yang [4793 7122] passed through Guangzhou on his return trip from visiting foreign countries, he specifically raised questions concerning the development of this project. In the following, I shall offer my comments on several of the problems:

(1) Why is it urgent to develop Hongshuihe quickly? The first reason is the urgent need for electricity. Guangdong is a special economic zone, with relatively rapid industrial development. The original industrial foundation of Guangxi and Guizhou is relatively weak but the energy and mineral resources there are relatively rich. While the development has quickened in recent years, in the future, the economic and industrial development of the 3 provinces will outpace the rest of the country, thermal and nuclear power will have difficulty meeting the needs. Fundamentally, [the 3 provinces] will necessarily depend upon the hydroelectricity of Hongshui to supply the needs for power. Second, there is an extreme deficiency of coal in Guangdong and Guangxi and the former does not have very much hydroelectricity either and its petroleum development is still in the prospecting stage. There is an urgent need to develop hydroelectrical power. Third, Hongshuihe is one of the rich resources of hydroelectrical power of South China as well as the most practical to materialize simultaneous development of primary and secondary sources of energy. Compared with the upper reaches of Huanghe which is agreed by everybody to be a rich source of energy, Hongshui is not at all inferior. Hongshui and Huanghe together form China's best foundation of hydroelectric resources at present. The development of Hongshui can basically resolve the energy needs of several South China provinces, and will also be able to export power to Hong Kong and Macao to exchange for foreign currency.

(2) Task of valley development and cascade development: Hongshuihe is China's most important source of energy and its development should primarily for power generation, combined with flood prevention, irrigation, and navigation objectives. We approve of the Hongshuihe cascade development formula in the report of the Guangxi Planning Office. The formula is reasonable with respect to the utilization of the energy resources and at the same time, sufficient consideration be given to the comprehensive utilization needs of flood prevention, navigation, and irrigation. We believe the formula should be approved. As the report is the fruits of many years of surveying, planning, and designing and does take into consideration the opinions and requirements of all aspects, it is in reality a part of the Zhujiang River Valley Plan.

(3) The cascade development schedule and short-term engineering arrangements: Judging from the introductions and speeches of these past few days, opinions concerning these matters are relatively close. The General Bureau of Hydroelectrical Power proposed to start the work of the low dam of Tianshengqiao next year, to be followed by the Yantan construction project, to be ready as soon as possible to coordinate the high dam with the low dam so as to be included in the State's 7th five-year construction plan. The early stage work of Longtan, Dateng, and other low-head cascades is to be carried out to prepare for future continuation. This arrangement is rather suitable.

(4) Concerning the problem of scale of Datengxia and Longtan: The height of the dams and the scale of these 2 hydroelectric power stations have presented some disagreements in recent years as well as at this conference. All agree on the 57.6 m designation of normal water level for power generation at Datengxia but there are diverse opinions regarding the flood prevention problem. Further arguments and discussions are needed. With regard to the height of the dam, the scale, and the construction stages of Longtan, the Feasibility Study Report of Central South Survey and Design Academy contains some detailed analyses. The academy has requested an examination of that report.

(5) Concerning the problem of economic benefits and the capital investment: Preliminary estimate indicates that if all the power generated by the Tianshenqiao low and high dam and Yantan power stations is to supply domestic uses, the capital investment including the investment for power transmission, may be returned with interest in 10 years following the beginning of power generation. If selling power to Hong Kong and Macao is to be considered, the period of capital return may be even shorter. In a word, the economic benefit is obvious. As much as possible, all the terraces should be completely developed in 20-30 years. Including the high voltage transmission lines, the capital investment is about 15 billion yuan;12.5 billion of it will be needed before the year 2000: one billion during the 6th five-year plan, 2.8 billion during the 7th 5-year plan. This capital must be gathered from various central, local, domestic, and foreign channels. We are considering the following: (1) A State basic construction loan; (2) Investments or loans from various provinces; (3) Trying to secure foreign low interest, long term, preferential loans; (4) Loans from Hong Kong and Macao to be paid by electrical power; (5) Taking on a portion of the capital investment by those to be benefited by the project;

(6) Asking Ministries of Metallurgy, First Machinery, and Chemical Engineering to negotiate compensatory trade with foreign countries. The various provinces and ministries are hereby requested to come up with some methods to raise the capital to develop the Hongshuihe project.

In the future, we must continue to do the survey, design, and construction work well. We hope all the provinces, prefectures, and departments will cooperate in the project of constructing power stations. When they are completed, the State will never forget everyone's contribution. We believe the Hongshuihe project will provide economic benefits for all provinces and regions and in the future, in the matter of constructing hydroelectric power, the economic benefits will be distributed fairly and reasonably according to the contribution in the construction process. We prepare to carry out some research studies and to talk with related departments to find some ways before we present a report to the State to request studies and implementation.

Liu Zhaolun [0491 0340 0243] (formerly Deputy Minister of the Ministry of Water Conservancy): The concrete policy of developing a segment of a river should be based upon the characteristics of that segment, as well as natural and economic principles. The natural conditions from Tianshengqiao to Laibin (including the lower reaches of Nanpanjiang and Hongshuihe) are uniform. There are high mountains on both banks, the valley is narrow, the terrain is high and precipitous, and the riverbeds are deeply cut. The relative subsidence is so great that 10,000 Mw of water energy may be developed to generate 50,000 million kwh of electricity a year. This is China's outstanding water energy resource of the south and the policy of developing primarily power generation, with flood control, irrigation, and navigation considerations is correct. From Fenghuangxia of Laibin to Datengxia, the river enters a zone of low mountains and low hills. The riverbed is flat and slow and shoals are developed. Crop fields stretch out on both banks and the population is relatively dense. The water system may be said to belong to Qianjiang. After it joins the branch of Liujiang, the drainage basin is 50 percent larger in area than that of the Hongshuihe valley. The water resources are even richer but the drop is reduced. Water power may be developed in a smaller proportion. Compared with Hongshuihe, the natural condition, the economic condition, and the area of effects are very different. The policy of development here should stress equal emphasis of flood control, power generation, navigation, and other considerations. The Tianshengqiao high dam and Longtan are proposed, in the Planning Report of the Hongshuihe Development Formula, as the major regulating center to coordinate with the various terraces of the lower reaches. This plan does correspond with the water resources development requirement. In a word, we approve. Concretely speaking, we approve the 2-stage development formula of Tianshengqiao dam; we approve of the stipulation that the normal high water level of the Longtan Center should not be lower than 400 m and the plan of reserving 10 billion m^3 reservoir capacity for flood control. Whether or not Pingtan (or Badu) cascade can be established may be determined at the time when the scale of Longtan is being decided. We approve of the 2-stage formula for Yantan and Dahua. Through further work and study, considerations may be given to possible enlargement of the construction scale of Wutan with the Bailongtan cascade eliminated. The problem of Qiaogong cascade involves the linkage with the Datengxia Center of Qianjiang; therefore, it cannot be resolved until the scale of the Datengxia Center is determined. With regard to the segment of Qianjiang, the proposal of the Planning Report of making Datengxia the chief water conservancy headquarters is correct. The construction of the Datengxia Headquarters is an important project of developing and controlling Zhujiang. It is a scheme for hundreds and thousands of years. It is, therefore, necessary to take a long term and overall point of viewpoint. Its flood control action, its conservation and drainage measures, and the coordination of the dam and the reservoir form an extremely important consideration in the flood control engineering system of the valley. So far as its flood control task and its capability of satisfying the navigation and transportation needs, disagreements still exist in the formula. Through technical and economic verifications, it should be possible to reach an agreement.

Concerning the development procedure, we basically agree with the proposal of the General Bureau of Hydroelectricity. As soon as possible, the Tianshengqiao low dam should resume construction. The repair work of the Yantan Hydroelectric Power Station should be given preferential consideration. With the reservoirs of the upper reaches, the stock pan of the Tianshengqiao high dam should be repaired and constructed first. Those who hold diverse opinions on the Datengxia Headquarters should prepare to negotiate to reach an agreement through more profound studies so as to hasten the first stage preparation work in view of the fact that it is an incomparable item of multi-purpose development. It should be possible to move the item ahead. The Longtan Power Station is a key engineering item of the Zhujiang valley, with the best regulating property, the largest machine capacity, and the most obvious flood control benefit. Its preparation work should be urgently carried out. Studies should be conducted to produce a formula for its development in stages and for handling the problem of compensation and resettlement of the areas to be submerged. The early implementation of this item also appears to be possible.

The development plans of Hongshuihe and Qianjiang Valleys contain many contradictions and one of the key problems is the problem of resettlement and compensation. Considerations must be given to reduce the losses from submergence so as to obtain greater comprehensive economic benefit. On the one hand, development and control requirements should not be overemphasized while overlooking the losses from the areas submerged by the reservoir; on the other hand the loss from submergence should not be regarded as an insurmountable obstacle for giving up reasonable requirements of development and control. The goal is not to overburden the State while keeping the relationship of the interests of the State, the local community, and the masses in balance. For the purpose of accomplishing that goal, we suggest that the problem of reasonable distribution of the benefits of water resources should be studied to ascertain a firm policy and to provide guarantees through legislation. The areas to be submerged by Longtan, especially the reservoir region of Datengxia, will include normal submergence and temporary submergence. The areas of normal submergence will be a long term total loss and the conspicuous problem is resettlement and compensation. The areas of temporary submergence are needed only when the reservoir is to regulate and deter flood water and the problems to be resolved concern various safety measures and compensation for temporary submergence. The latter is a totally new problem and there is no experience in handling it. Serious studies should be carried out to seek a reasonable solution.

Weng Changpu [5040 7022 3302] (Director, Kunming Survey and Design Academy, Ministry of Electric Power): The goal of Hongshuihe development is mainly to generate electricity, with flood control and navigation as the secondary considerations. This is a realistic goal and is arrived at through a tortuous practice. The development policy and the way of taking care of the submerged areas proposed in the Hongshuihe Comprehensive Utilization Plan Report of Guangxi are the fruit of studies and reversals of a prolonged period of time. It is a relatively correct conclusion. The various stages of development are the result of a great deal of work performed by the various survey and design academies after spending a long time to bring the work to a level surpassing that of the planning stage. The plan should be affirmed. The outward form of the plan was contrived during the third quarter of 1978 when the leftist influence had not yet been totally cleansed, however, and the work on cascades between Dahua and Datengxia remained relatively superficial. These are not such urgent matters. however, and there will be time in the future to discuss and decide.

Hongshuihe itself has superior power generating characteristic but the machines of some stations appear to be too large and to contain excessive seasonal capacity. Under the condition of not including Longtan Reservoir in the first stage construction, the total machine capacity of Hongshuihe should be appropriately reduced, otherwise there will be difficulty in harmonizing with the needs of the power users.

With regard to the problem of flood control, some of the regulations of the draft Regulation of Water Conservency Hydroelectric Power Engineering Motive Power Design, issued by the former Ministry of Water Conservency and Electric Power in 1977. should be repealed. Regarding the matter of seeking benefits and avoiding the harm of flood water, the practical experience and wisdom of the masses should be depended upon to bring about adaptation to nature and to give up the absolute notion of using engineering to control flood.

With regard to navigation, the upper reaches of Wutan are historically basically not navigable except for floating logs. Hongshuihe should not be thought of as the important waterway connecting Yunnan-Guizhou with Guangdong-Guangxi. It is only an alpine inland lake - a channel without an outlet. Thus, we suggest that based upon the existing locks of Wutan, Qianjiang Datengxia below Dahua should be designed for towing boats of 500-ton class over the dam.

With regard to the development schedule, we agree with the plan of constructing the Tianshengqiao-Yantan group first. Due to the fact that the regulating capacity of the Tianshengqiao reservoir is inferior only to that of Longtan, early benefit may be obtained. The scheme is reasonable and the design is concrete. We are only waiting for the construction to resume. Meanwhile, with Tianshengqiao, thermal power station of Pan County may be quickly connected with the Hongshuihe hydroelectric power.

Cui Zongpei [1508 1350 1014] (Deputy Chief Engineer, Bureau of Planning, Design, and Management, Ministry of Water Conservancy): After listening to the introduction from comrades of Guangxi and reading some of the materials, we understand that comrades of Guangxi have gathered a great deal of data and performed a great deal of work of supplementing, analyzing, and studying and made a great achievement in finally producing this book of Planning Report. Due to the fact that I have only a scant understanding of the condition, I can only express some rather superficial opinions concerning my positive support for the Hongshuihe cascade development project.

Hongshuihe is a "rich mine" among water energy resources. Based upon the concrete condition of the various segments of Hongshuihe, the Planning Report arranges 10 cascades to suit the different locations and selects the 5 cascades of Tianshengqiao high and low dams, Longtan, Yantan, and Datengxia for development in the near future to form the backbone of the engineering project. This is a proper proposal. I suggest the following with respect to the development schedule of the cascades for reference: (1) The 8-year construction period for the Tianshengqiao low dam seems to be rather long. Perhaps it may be shortened one or two years so that power may be generated 1-2 years sooner. (2) It may be feasible to delay the arrangement of Longtan a little but it seems to be too late if electricity cannot be produced by the end of this century. I hope that the suggestion of development in stages may be studied to make it possible to produce electricity by the end of the century. (3) The Datengxia has comprehensive benefits of power generation, flood control, navigation improvement, and irrigation and all concerned are hoping for its early development and utilization; therefore, further research is needed concerning the plan of not generating electricity within this century. With respect to measures to accelerate development, the pace of the preparation work of the various stages should be quickened. There should be detailed and full technical and economic verifications of such basic data as the hydrology, geology, etc. according to the requirements of the basic construction schedule in order to produce research reports and design documentation that are capable of being implemented. Especially with regard to the problem of resettlement of the inhabitants, there should be a resettlement plan to find a suitable place for everyone so that their production and living standards will not be reduced. In view of the difficulty of raising construction capital in our country at present, I suggest that aside from fully utilizing domestic loans, foreign investment should be used. This is also a possible route for developing the water energy resources of Hongshuihe.

Jia Xiudian [6328 0208 0368] (Deputy Director, Research Academy of Water Conservancy and Hydroelectricity): The overall policy of Hongshuihe development should mainly be power generation, to combine it with comprehensive utilizations. The hydroelectric power is to supply the 3 provinces and region of Guangxi, Guangdong, and Guizhou; to others only if there is a surplus. The characteristics of the 3 provinces and region are somewhat different. Guangxi has water but no coal; Guizhou has both coal and water; Guangdong has no coal and her water is just about all developed. The common characteristic of all 3 provinces and region concerning water power is poor stability. In other words, a great deal of hydroelectricity is seasonal. Guangdong originally has some regulating reservoir capacity but this has been pulled away by small hydroelectric projects. Hence, except for Guizhou, both Guangdong and Guangxi have been troubled by power deficiency; during a dry season, life depends upon fuel power but these are also areas of coal deficiency. There is a coal shortage every year now. If the development of thermal power is to continue what is to do in the future [where can coal be found in the future]? Hence, an independent hdroelectric power system, requiring no coordination with thermal power plants should be developed. If this is not so, the situation will sink deeper and deeper and the only result will be no hydroelectricity and it will be costly even it it is to be built. There is a great deal of repetition in water and thermal power and the cost of unit kw construction cannot be reduced.

The second policy, therefore, is of necessity to develop a hydroelectrical system capable of independent operation and capable of being regulated. This is the only way to satisfy the power needs of the near future. That is to enlarge the proportion of hydroelectricity step by step in order to reduce the consumption of oil and coal (and not to increase the consumption of oil and coal.)

The first stage construction should be selected according to the speed of increase of electric power permitted by the available capital of the State when we start out from this policy. The first requirement is reservoir capacity and not machine capacity. The likes of tributary power stations such as Basuo, Yantan, Datengxia should not be built first even if they require less investment and show benefits fast. The only choice is Tianshengqiao first terrace (Bapian) and Longtan high dam (more than 400 m in elevation, not below 375). It is a choice between the 2 power stations. Although Longtan has many advantages, the construction is large and investment high. It will take a long time to build and is highly difficult technically. It is, therefore, completely reasonable to put Tianshengqiao in the first place.

With regard to the problem of whether a unified leadership organization should be established for the Hongshuihe Project, a coordinating organization is indeed necessary to provide better planning, to give unified consideration of environmental problems, and to make arrangements of industry and agriculture. There will also include problems of water and soil conservation, communication and transportation, the flow of materials, the development of agriculture and forestry in the mountainous regions, etc. With respect to the problem of submergence, resettlement, and compensation, it involves the problem of regional development. If the problem of regional development is not resolved, the problem of population resettlement cannot be resolved. If the problem is resolved well, the income from forestry and mountain products may exceed the income from farming. With respect to flood control, the former Ministry of Water Conservancy and Hydroelectric Power had enacted regulations. In concrete application, there should be flexibility according to local conditions. The losses due to submergence in the upper and lower reaches should be reasonably shared. For example, whether or not it is feasible to exchange the submergence loss of the Zhujiang Delta with the submergence loss of the area above Datengxia is a question worthy of contemplation. The answer to this question may be argued and verified by economic analysis, but the data should be accurate and the computation equations should correspond with the reality.

Zhang Guangdou [1728 0342 2435] (Professor of Qinghua University): In river valley planning, there should be an emphasis on economic analysis and formula comparison. The construction investment cost proposed in the planning report should take into consideration of interest, computed by the compound interest principle. As to the problems of raising the construction capital, distributing investment on the basis of comprehensive utilization, compensating land submerged by reservoirs, and resettling the inhabitants, etc. there should also be serious studies before making arrangements.

I approve of the plan of the Hongshuihe Project to be mainly for generating power, with secondary considerations of flood control, navigation, etc. and the construction sequence proposed by the Ministry of Electric Power to build the Tianshengqiao Hydroelectrical Power Station and the Yantan Hydroelectrical Power Station first. It is reasonable to make Tianshengqiao high and low dams into one group of power stations. The engineering of Tianshengqiao is relatively simple, the involved area is small, the problems can be easily stated, and more preparation work has been done; therefore, it should be implemented first. There remain problems of accelerating the construction speed, the arrangement and training of teams of construction workers, etc. The capacity of Longtan Reservoir is large and the power generating capacity is high. It will be the nuclear engineering of the Hongshuihe Project. As the Longtan large dam is a concrete gravity dam of 265 m in height, attention should be given to the engineering geology problem. In designing and planning, the enrockment type dam should also be considered. In so far as the problem of developing Longtan in stages, it is not such a simple problem and it complicates the engineering project. All that should be clearly explained to the leaders. The total investment cost will be greater and it is not that simple to operate the power plant in stages. I am not saying that it is not possible but overall considerations are necessary. Datengxia is located in the lower reaches. Its comprehensive utilization is important but many contradictions exist. The planning work should be carried out in more minute details. Several formulas for power generation, flood control, navigation, etc. should be produced for comparison before making choices.

Zhong Dehun [6945 1795 5478] (Deputy Director, Water Transportation Planning and Designing Academy, Ministry of Transportation): The condition of natural navigation of Hongshuihe is poor. At present, only motor boats below the 30 tons class can navigate through it above Wutan; below Wutan navigation is possible for boats of 120-250 ton class. The annual transport volume is about 7 hundred thousand tons. The resources of the Hongshuihe Valley are abundant, however. For example, the coal of Guizhou Province is in need of being shipped out and the energy deficient region of Guangdong and Guangxi is in need of receiving coal. The provinces of Yunnan and Guizhou produce a good deal of phosphate rock which is needed in Guangdong and Guangxi. The 2 railways of Gui-Kun and Qian-gui have capacities of 5.10 million and 4.2 million tons respectively and are both in a saturated state. Problems of autoignition of accumulated coal in Guizhou, deciding production of phosphate rock on the basis of transportation capacity in Yunnan and Guizhou, etc. have occurred. Even if such methods as railway electrification is adopted to raise the railroad capacity, the transportation needs cannot possibly be met. Hence, the plan of shipping coal and phosphate rock through Hongshuihe down to Guangdone and Guangxi is reasonable in so far as the sources of cargo are stable and plentiful and the direction of flow is correct.

Based upon a calculation of the water transport volume and the technical condition of Hongshuihe, the following is my opinion concerning the navigation standards of the various grades: Boat lift of the 300 ton class should be constructed at Longtan; in Yantan, Dahua, Bailongtan, Wutan, and Qiaogong, locks of the 500 ton class should be constructed; there should be a lock of the 1,000 ton class at Datengxia. After all the cascades of Hongshuihe Project are completed, a deep water channel of 800 km will be formed to link the Southwest with South China. The annual capacities will be as follows: The section above Laibin will reach 6-7 million tons; the section above Datengxia will reach 12 million tons. The investment per km will correspond with about 1/3 of that of railway construction for that region. The unit transport cost (the cost of the Liuzhou Bureau for 1980) will be 20 percent lower. More than 10 million yuan in transportation expenditure will be saved in a year. Hongshuihe is the equivalent of a major river in Europe or a major tributary of the Mississippi in the USA; therefore, in deciding such problems as the locations of the graded cascades, the division and connection of the water levels, the arrangement of the headquarters, the downward flow volume, and construction schedules, the navigation requirements should be given ample consideration.

Guangxi Research Institute of Marine Products: Hongshuihe has about 60 species of fish. Judging from the contents of nutrient salts of the water, the river belongs to a poor nutrient type, only calcium, sulfur, silicon, and ammonium salts reach the medium level. Judging from the actual production volume and the computed volume from evaporation, from reservoirs in the region of Guangxi (Qingshitan, Dawangtan, Chengbihe) 1 jin of grown fish per year may generally be caught from every 2,000 m^3 of water. Thus, the fish production of Hongshuihe may be estimated at 12.5 million jin, i.e. 6,250 tons/year. That would be 3 times the total freshwater fish production of the entire region at present.

The construction of 10-grade Hongshuihe hydroelectric power stations will certainly bring profound effects on the ecological environment. Propagation of some species will be lost. For example, in the 15 years following the completion of the Xijin Hydroelectric Power Station, the average annual reduction of fingerling production reached 14.48 percent. The reduction of yield of freshwater fish has many causes and cannot blame entirely on dams. Judging from the fact that rivers of Guangxi have many shallow shoals and deep pits, the spawning sites and overwinter sites are very much scattered, almost all over the major segments of the stream. Aside from some long distance, up and down river migrating species, most others have the ability of adapting to the new environment following the completion of dams, however. For example, in areas not very far above and below the Xijin Hydroelectrical Power Station dam, domestic fish finglings may be caught to this day. After the spawning site of Parabramis pekinensis (Basil) near Nanning was lost, members of that species have voluntarily moved to the upper reaches of Youjiang. All is needed is to strengthen the administrative management of the fishery waters, freshwater fish resouces can be expected to recover. Meanwhile, when the water level is raised by the dam, the area of the water is increased and the flow speed is reduced. This condition is favorable for the multiplication of marine organisms, especially in several years after the dam construction. Based upon the current financial condition of China, we believe facilities for the passage of fish need not be emphasized in every section of the 10 cascades of Hongshuihe.

Appropriate consideration should, instead, be given to measures to enlarge the marine product resources. With the Datengxia Hydroelectrical Power Station, there is the relatively important fishing industry of Liujiang and Rongjiang, while above and below the dam there are two nationally famous large spawning sites of domesticated fish. We, therefore, suggest that facilities for fish passage should be built at Datengxia. We also suggest that in the designing work, considerations may be given, wherever engineerly possible, to the need of constructing hatcheries and to raising fishes in reservoirs, including for example, flat bottom sites for raising fingerlings and baiting grown fish, setting up obstacles in the spillway to prevent fish from escaping, etc.

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CSO: 4013/61

PHOTOGRAPHS SHOW SITES, PROGRESS OF HONGSHUI POWER PROJECT

Beijing SHUILI FADIAN [WATER POWER] in Chinese No 4, 12 Apr 82, centerfold

[Photographs and Captions]

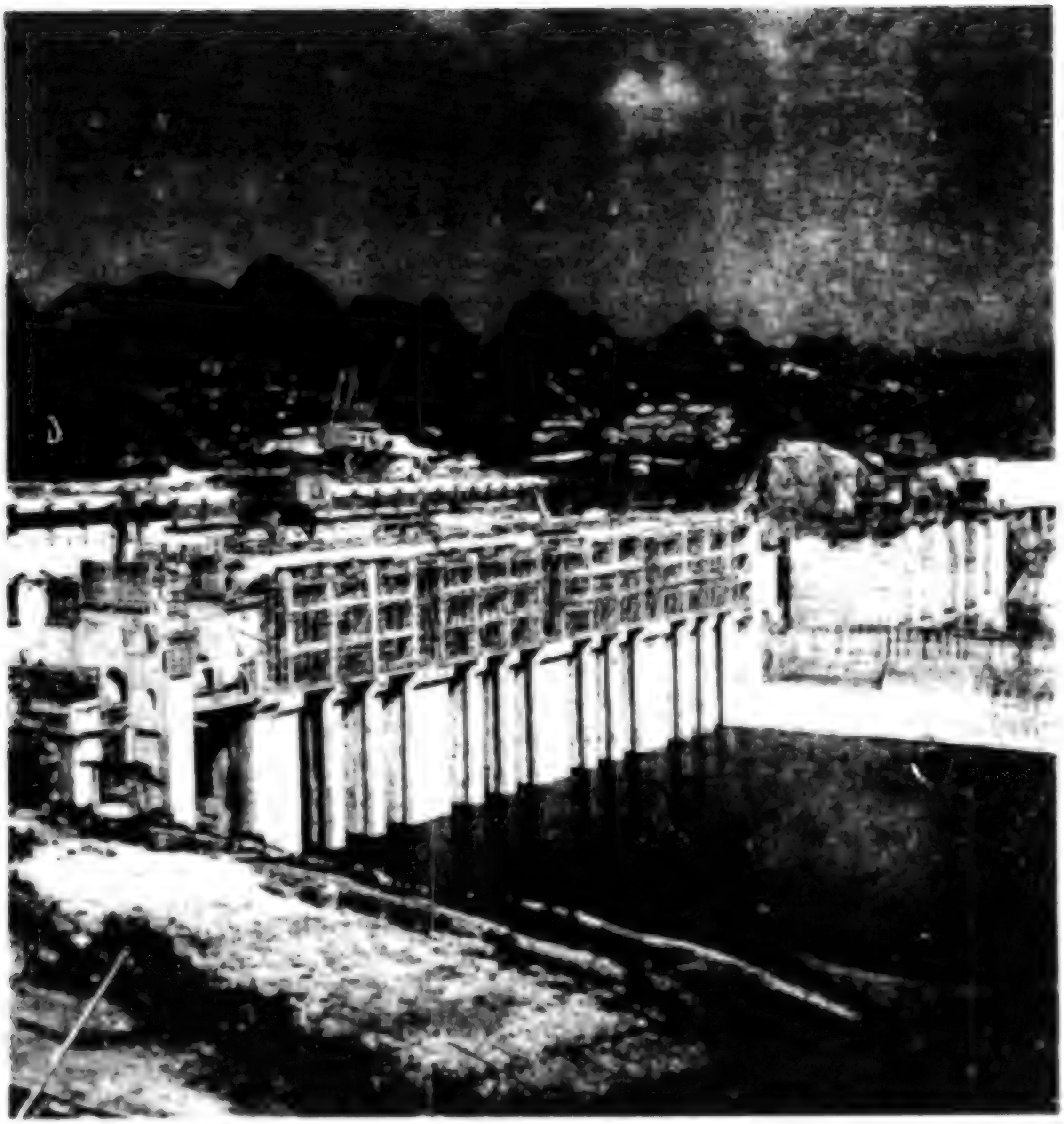
Overview of the Yantan Hydroelectric dam site.

Site of Tianshengqiao Hydroelectric dam.

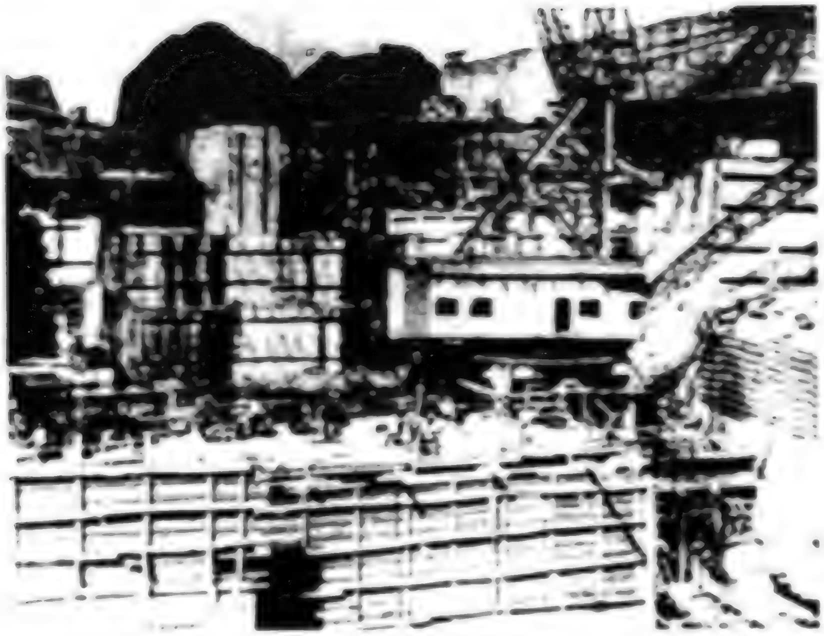
View of site of the Longtan hydroelectric dam.

Overview of Etan hydroelectric power project.

Installing of generator at Etan hydroelectric power project.

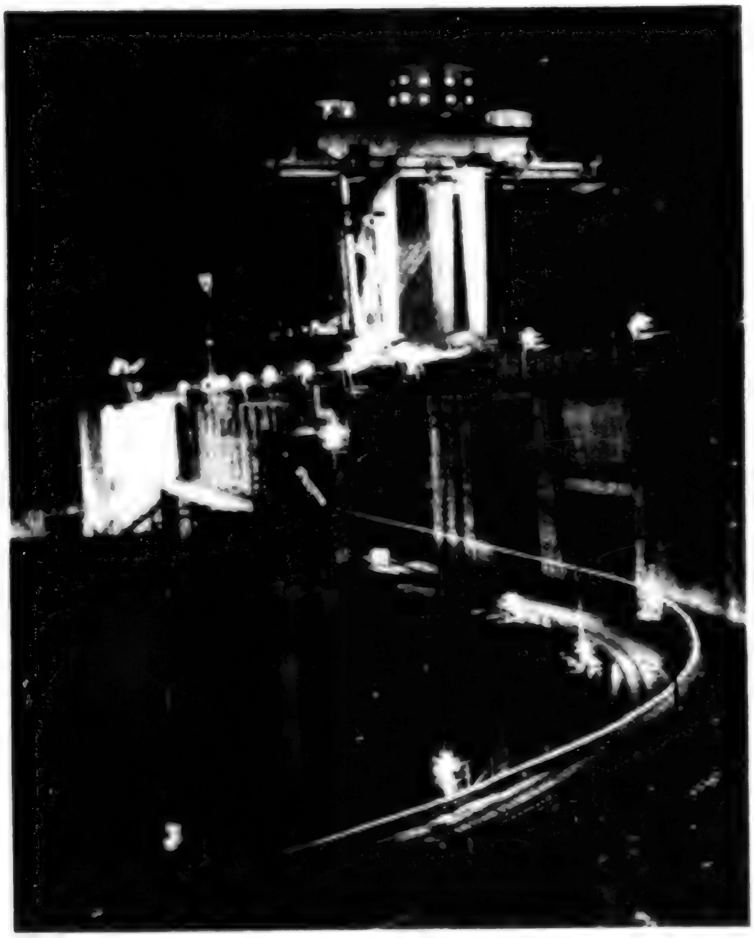


[illegible] hydroelectric power station.



A section of the construction site of Dahua hydroelectric station.

State of progress of Dahua hydroelectric station.



Dahua hydroelectric power project at night.

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PRINCIPAL EXPERIENCES IN PLANNING THE DEVELOPMENT OF HONGSHUI RIVER

Beijing SHUILI FADIAN [WATER POWER] in Chinese No 4, 12 Apr 82 pp 9-14

[Article by Office of Water Conservancy and Electrical Power Planning Group, Guangxi Zhuang Nationality Autonomous Region]

[Text] Hongshui River is the main waterway of Xijiang water system of the Zhujiang Valley. It originates in the Yunnan-Guizhou Plateau and flows through the realm of Guangxi. Its drainage basin is broad, with superior natural geographic conditions. It is a rich resource of water energy. Since the liberation, under the leadership of the party and the people's government, several surveys and planning programs have been conducted to accumulate a large quantity of information. With the advancement of the national economy, many have demanded urgent comprehensive utilization of Hongshui River. The party committee of the autonomous region thus resolved in 1978 to establish the Water Conservancy and Electrical Power Planning Group. Technical members of departments of water conservancy, electrical power, transportation, geology, etc. were assigned to form the special planning organization and to be responsible for the overall planning work of the Hongshui River Comprehensive Utilization Project. At that time, aside from the fact that Dahua Hydroelectrical Power Station was under construction, the Central South Survey and Design Academy of the Ministry of Electrical Power, the Guangxi Hydroelectricity Bureau Designing Academy, the Northeast Survey and Design Academy of the Ministry of Electric Power, and the Ninth Bureau Designing Academy were also conducting survey

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The paper is the result of discussions by Su Weidian [5685 3634 0368] Su Zhu [5685 3137] Guang Yaohua [0342 5069 5478] Cha Qichang [2686 0366 2490] Lyu Zuhong [0712 4371 1736] He Fujun [0149 4395 0193] and some other comrades of the Office of the Planning Group. Lei Kai [7191 7030] provided some written materials and the paper was panned by Guang Yaohua.

and designing work at Longtan, Yantan, Datengxia, and Tianshengqiao. Under the cooperation and coordination of the various units, the Hongshui River Comprehensive Utilization Plan Report was completed in Mar 80, following more than [illegible] years of efforts. In Oct 81, a conference was called under the auspices of the National Committee of Energy Resources and the National Planning Committee to examine the aforementioned report. The participants of the conference discussed the development policy of the Hongshui River project, the scheme of terraced stages and development sequence of the power stations of the cascades and arrived at basically uniform viewpoints. Afterwards, the State Council quickly reviewed the report of this conference and in the review document the following was clearly stated: In general, the development policy of Hongshui River is primarily for power generation, with secondary considerations of flood control, navigation, irrigation, marine products, etc. for the benefit of comprehensive utilization. The document especially emphasized that the development of the water energy resources of Hongshui River is a strategic measure to resolve the problem of source of energy in South China. It should be included in the 6th -year plan and the long range plan be carrried out orderly and in planned steps. This is an expression of great concern for us, the people of various nationalities of the banks of Hongshui River and in Guangxi, Guangdong, and Guizhou. We are determined to work hard for the realization of the directive of the State Council. We will let this "pearl" of the South serve our country's socialist modernization construction as early as possible to bring benefits to the people. The following is a summarization of our understandings in the Hongshui River planning work:

I. Collection and Analysis of Basic Information

For the purpose of developing and utilizing the water energy resources of Hongshui River, the survey and planning work began in the early 50's to inspect selected points of the stream. In these 20 years, a large amount of data concerning the topography, geomorphology, geology, hydrology, meteorology, navigation, irrigation, ecology, natural resources, and social and economic aspects of the Hongshui River Valley have been gathered and more than 20 dam sites have been chosen. More than 10 organizations involving close to a thousand persons participated. These persons walked all over the mountains and waters of the Hongshui Valley. They worked very hard for the project.

The incomplete topographical map of a scale of 1 : 50,000 made before the liberation is of poor quality and cannot serve as the basis for the planning work. Beginning in 1956, a large group of surveyors, therefore, climbed up the mountains and under the condition of extreme hardship, they surveyed and drew a topographic map in a scale of 1 : 25,000, covering several thousand km^2, from Hongshui River to Tianshengqiao, to Datengxia, including 1,238 km of vertical sections and 284 horizontal sections of channels of both the main and the branch waterways to provide the basic information for statistical computation of the reservoir capacities and the backwater.

Before the liberation, the geological work of the Hongshui River Valley was basically a blank. As the valley planning work proceeded, geological survey teams of related organizations repeatedly went to Datengxia, Longtan, Yantan, Fenghuang, and Tianshengqiao to draw geological maps of the reservoirs and dam sites of the various grades and to perform bore prospecting work. In view of the karst development characteristic of the Hongshui River Valley, the geologists paid special attention to the inspection and study of karst geology. They traced underground hidden streams as long as several km and dropped into karst vertical wells as deep as 160 m to gather first hand information of several hundred karst caverns. With almost no motorized vehicle, the bore surveyors brought equipment, weighing tens of tons into the mountains of extremely difficult transportation conditions to struggle in the outdoors for months and years. According to statistics, in these 20 plus years the various organizations performed more than one hundred thousand m of bore prospecting work for the various stages of power stations of Hongshui River. They drilled more than 1,200 holes, prospected 13,000m of wells, and drew 9,000 km^2 of geological maps in a scale of 1 : 25,000. They also carried out 2,200 rock mechanics tests to provide important verification data for comparing dam sites and selecting formulas.

Before the liberation, there were few hydrological stations in the Hongshui River Valley. Since then, due to the needs for stream development and other construction projects, a large number of hydrological and water level stations have been gradually established. Observation data for 30-50 years of 77 hydrological stations and water level stations, and 271 rainfall volume stations are used in this plan.

During the planning period, the aforementioned information, the prospecting reports, the maps, tables, and statistical figures were systematically compiled. Most of these raw data coincide with the objective reality but some of the data cannot meet the needs of the planning work. A process of elimination and analysis was therefore required. More importantly, as the various items of construction proceeded, many departments had continuously published new materials. For example, 1 : 50,000 aerial survey maps of relatively high quality are now available for all of Guangxi. The 1 : 10,000 aerial topographic maps of the middle and lower reaches of Hongshui River are also completed. The 1 : 200,000 regional geological hydrogeological maps are also useful. The lithofacies maps, karst maps, tectonic maps, and earthquake classification maps compiled by us, the satellite photos, and the aerial photos are all important for analyzing and evaluating the Hongshui River engineering geology conditions. Detailed and carefully classified hydrological information has also been gradually published. Some related organizations also made surveys of flood history, silting, drought and flood damage, mineral deposits, earthquake, etc. studies of Hongshui River. The information concerning transportation, navigation, and power load also form important references in our planning work.

Mastering reliable basic information is the necessary prerequisite of good waterway planning. In order to plan the construction of large scale power stations of tens of millions Mw, the basic information should, of necessity, be precise to a certain degree. As soon as the planning work began, we emphasized the strict implementation of related regulations and standards. We did not propose excessive demands but we required a degree of precision corresponding with the planning stage work. Aside from full utilization of available data, all terraces and dam sites that had no or very little existing data should be covered with topographical surveying, geological surveying and mapping, and bore prospecting work. With regard to losses of reservoir submergence, the

Datengxia and Wutan cascades were regarded as the key points to proceed with typical investigation, to compute the growth rate of population and land, using past survey figures to derive the current levels. It should be pointed out that when the Hongshui River Planning work was being carried out, the related bureaus and academies were also conducting survey and design work for several other large power stations. They supplied us many new data, especially information concerning geology, reservoir submergence, and headquaters arrangement so that the information of the planning work could be checked and verified quicker and the precision of the results was thus improved.

II. Hongshui River Development Policy Ascertained On the Basis of Real Conditions

The way the Hongshui River development policy is to be determined had been the central problem of discussion throughout the planning period. After several discussions, we gradually recognized the fact that the problem should be considered on the basis of the actual conditions of the river, the relationship between the upper and the lower reaches, the distribution characteristics of resources in Guangxi, the needs for regional economic development, etc. It was, therefore, a consideration of multiple and complex factors.

Although the planning report proposed toward the end of the 50's also mentioned the objective of such comprehensive utilization as irrigation, flood control, power generation, navigation, etc. in the resultant plan a series of high dams and large reservoirs were arranged in the middle and lower reaches of Hongshui River, which is the main channel of Xijiang. The regulating property of the plan seems to be very good. It has great flood holding action. The loss from submergence by reservoirs is extremely severe, however. For example, the normal water level of Fenghuang reservoir is at 129 m and that of Datengxia 75 m. According to the survey information at the time, more than 540 thousand mu of cropland would have been submerged by the 2 reservoirs and 280 thousand inhabitants moved (there has been a considerable increase since then.) Considering the scarce land resource condition of Guangxi, it is difficult to implement such a plan. The plan of the early 70's proposed the construction of a Hongshui River steel and iron transportation line, with primary emphasis on navigation. With overemphasis on reducing the loss from submergence, low head power stations were arranged from the upper to the lower reaches while neglecting to plan the necessary reservoirs. The loss from submergence was reduced, but the water energy resouces were not fully and reasonably utilized. The machine capacity and the annual power production were less than half of the current plan. Thus, much of the water energy would have been seriously wasted while the needs for the development of the national economy would not have been met. This plan was impossible to be implemented either. These facts demonstrate the importance of ascertaining a correct stream development policy.

The current plan absorbs the lessons of experience of the previous ones. On the basis of surveys and studies and the real conditions thus mastered, the plan proposes a policy of primarily power generation, with secondary consideration of such comprehensive utilization benefits as flood control, navigation, irrigation, marine products, etc. This conclusion is based upon the following:

(1) The water volume of Hongshui River itself is very large; the grade of the

slopes is steep; the drop difference is concentrated. In a word, it is a river containing water energy in abundance. The machine capacity of the section from Tianshengqiao to Datengxia capable of being developed reaches 1,100-1,276 Mw, with guaranteed production of 550-640 Mw and an annual power production of 600,000-540,000 MWh, amounting to 50 percent of the total power capable of being developed in the entire Zhujiang Valley, and 72 percent of that of all Guangxi. The conditions for development are good; the loss from submergence is relatively small; the transportation and construction conditions are convenient; the distance from power user centers is short. Concentrated development is, therefore, possible to make it a hydroelectrical base.

(2) Guangxi is deficient in coal and petroleum resources. The known coal reserve is only about 20,000 million tons. It is of poor quality with high ash content and low heat capacity. The province depends excessively on coal shipped from outside to develop thermal electric power. The difficulties are numerous. Under this condition, the development of hydroelectrical power with all-out efforts coincides completely with the country's policy of developing energy sources that are locally suitable.

(3) Guangxi has rich deposits of nonferrous and ferrous metal deposits, of which the tin, lead, zinc of Dachang, the aluminum of Pingguo, Daxin, and Laibin, and the manganese of Guiping are all rated first in the nation. Refining these metals consumes a great deal of power. There must be a stable source of electricity; therefore, full development of low cost hydroelectricity of Hongshui River is the only way to make mining and refining the colored metal deposits possible.

(4) The Hongshui River Valley is the home of minority nationalities and it is also an historical base of revolution. The production is backward the economy under-developed. The development of Hongshui River, therefore, also has specially important political and economic significance.

(5) At present, there is a shortage of electricity in Guangxi and Guangdong. In view of the resources condition, the problem can be resolved by transmitting hydroelectricity from Hongshui River. Moreover, with the development of Hongshui River, electricity may be sent to Hong Kong and Macao in exchange of foreign currency. This is an incomparable advantage over other hydroelectrical sources of the country.

(6) For Hongshui River itself, the damage from floods is not very serious. The target of flood control is mainly the banks of Xunjiang and Xijiang of the lower reaches. Due to the fact that the upper reaches of Hongshui River are relatively far from the Zhujiang Delta, the area to be controlled, such as the Longtan cascade level, amounts to only 20 percent of the area of Zhujiang Valley. For this reason, it is difficult to develop a greatly effective flood control project. Although the area of control of the lower reaches of Hongshui River, such as Datengxia level, is relatively extensive, it is in a hilly plain, with concentrated cropland and a dense population. The construction of a large flood control reservoir is; therefore, not suitable. It is not reasonable to propose an excessively high flood requirement. The plan policy is, therefore, mainly for drainage. Combining dams and reservoirs, the policy

is to give some consideration to water storage to take care of both the upper and the lower reaches. A proper amount of flood control capacity is reserved in the Longtan and Datengxia reservoirs. With this regulating capacity of the reservoirs and adding height and strength to dikes in the lower reaches, flood damages to the lower reaches will be greatly lessened. This is how, under the primary concern of power generation, the needs for flood control are taken care of as well.

(7) Due to the large number of shoals and swift water flow, the navigation condition of Hongshui River is very poor. The cargo transport volume of the river has always been very small. Although the prospect of increase has been growing, the only way to improve the navigation condition is through the development of multi-staged hydroelectrical power stations in the river.

(8) The upper and middle reaches of Hongshui River flow through and over alpine ravines and karst peaks. Croplands are scattered and there is no large irrigated acreage. Plans for gravity irrigation facilities are not necessary. Generally, it is more suitable to use local runoff or ground water. After the graded reservoirs are built, the water of the reservoirs can be pumped for irrigation. Gravity irrigation programs may be developed in the lower reaches, however. This subject may be studied in the future.

In conclusion, the policy ascertained in this plan is primarily for power generation, with secondary considerations of flood control, navigation, irrigation, marine products, etc. to obtain comprehensive utilization benefits. It is based upon the natural characteristics of Hongshui River and the conditions of reality in the valley. It is formulated in accordance with the national energy policy and the needs for the development of the national economy, following 20 years of investigation and practice in a step-by-step process. We believe, by following this policy, the positive implementation of the Hongshui River Project will give all other construction projects of South China a very powerful push.

III. A Reasonable Cascade Arrangement Based Upon the Characteristics of the Natural Condition

As it is a common knowledge that there is karst development in Hongshui River Valley, areas of carbonate rocks take up 67 percent of the surface. The problem of leakage of reservoirs, is, therefore, a key subject in hydroelectrical construction. It must be handled with caution. In the plan, attention is given to the current condition of karst development and a study of its basic regularities. The effects of the more than 90 hidden underground streams of both banks of Hongshui River on the seepage of the reservoirs of various grades are analyzed. On the selection of sites for headquarters, karst regions are avoided as much as possible and the choices are on sandy shale or lava rocks. For example, the sites of power stations of major grades, such as Tianshengqiao, Longtan, Yantan, Dahua, Datengxia, etc. are all located on sandy shale and diabase with relatively good water barrier conditions. With some grades, due to the need of connecting the water levels, it is necessary to choose the dam site in the limestone. In these cases, sites of relatively weak karst development and sections with a relative barrier stratum are selected. For example, Wutan and Qiaogong are chosen in the flint limestone of Qixia stage, of the

Permian System, where karst is not very developed. At the same time, the head is appropriately lowered so that the reservoir will not exceed the stream trough. In this manner, the possibility of karst seepage is reduced to the minimum. In the process of comparing the dam sites, the arrangement of the headquarters, the conditions for construction, the extent of losses due to submergence, and many other factors are also taken into consideration. Based upon the characteristics of large volume flood peaks and great variations of water level of Hongshui River, the dam sites are generally chosen in relatively broad sections of the valley, with thick and strong banks and shoals to meet the needs for drainage and construction work. This condition is favorable for generating power in an earlier date. Based upon these principles, through comparison, and out of [illegible] originally chosen sites, we choose 10 relatively better sites for the dams.

The water energy of Hongshui River is rich, but its reasonable development and utilization depend upon the reasonablenss of the terraced development formula. The experience of hydroelectrical construction in Guangxi serves as a lesson to teach us that it is necessary to build large regulating reservoirs for the full utilization of the water energy and at the same time losses due to submergence must be reduced as much as possible. This is one of the important principles repeatedly imposed by the Guangxi Regional Party Committee with respect to stream planning work. Since the liberation, 10 medium and large power stations at Xijin, Mashi, Luodong, etc. have been built and all are low head runoff power stations. The production guaranteed during dry season is deficient. Since [illegible], during the dry season of every year, Guangxi has a power shortage of more than [illegible] Mw and industrial and farm production has thus been seriously affected. If large reservoirs of good regulating property are not constructed on Hongshui River, the passive situation of power shortage during dry season will be with us still. On the other hand, during the high water season, a large quantity of seasonal power will have no outlet and the water of the Hongshui River, rich with energy, will have to flow away in vain. This is the reason for constructing large reservoirs of good regulating capabilities. It is both urgent and necessary. In Guangxi, there are many mountains and few lands. The unit yield is low. The agricultural production is backward. Excessive losses due to submergence just cannot be permitted. This problem is even more important for the hilly plains of the middle and lower reaches of Hongshui River. In order to resolve this contradiction, an overall consideration is necessary to weigh the gains and the losses. The way we handle it is as follows: With respect to the high dams and large reservoirs of better regulating capabilities of the alpine ravines, in the upper reaches of sparse population, the emphasis is on providing greater guarantees. In the middle and lower reaches of hilly plains, low head riverbed type runoff power stations are planned so that the backwater will not flow out of the river trough. Moreover, low dams and high locks are adopted as measures to limit the water level of the flood stage so as to reduce losses from submergence to a minimum. After the flood, the water level is raised again to increase the power production.

In handling the contradiction of producing more power and submerging less land, more profound considerations have to be given to determine the correct scale for the power stations at Longtan and Datengxia.

Longtan is located in a grade of the upper reaches of Hongshui River, where the population is sparse. The region controls several large tributaries above the South and the North Panjiang and Tiane. The areas of the reservoir and the dam are of sandy shale, with good geological conditions. In Mar 81, the Ministry of Electrical Power called a Longtan Dam Site Selection Conference. The participating geological and hydrological specialists all agreed that Longtan has the condition for constructing a high dam and a large reservoir. The Longtan Power Station will by itself have great economic benefits and high indices. Through regulation by the reservoir, it can offer guarantees to the various grades in the lower reaches. For example, at the normal water level of 400 m, the reservoir capacity is 27,500 million m^3 and is capable of multi-year adjustment. The machine capacity of the power station is 400 Mw, with 1[illegible]3 Mw of guaranteed power output and an annual power production of 181 MWh, and with regulation of the reservoir, the station can guarantee the various grades of the lower reaches 165 Mw to increase the annual power output of 55 MWh. When the normal water level is at 440 m, the reservoir capacity is 55,600 million m^3 and the machine capacity is 600 Mw to guarantee an output of 23[illegible] Mw with an annual power production of 231 MWh. The increase guaranteed to the grades of the lower reaches is 176 Mw to raise the power output of 66 MWh a year (all the indices of the Longtan Power Station are based on the condition of independent operation.) The reason for Hongshui River to be a "rich mine" of China's water energy resources is mainly for having this Longtan Power Station. It is not replaceable by any other power station on that river. The loss due to submergence in Longtan is relatively small. With the 400 m scheme, 55 thousand mu will be submerged and 64 thousand persons have to be relocated, averaging 233 mu and 271 persons per 100 MWh. With the 440 m scheme, the land to be submerged is close to 95 thousand mu and 99 thousand persons have to be relocated, averaging 318 mu and 333 persons per 100 MWh of power. This is a much lower index than other power stations of this class. According to statistical data of 11 medium and large power stations that have been constructed or are under construction, the average is 5,900 mu submerged and 4,170 persons relocated per 100 Mwh of electricity, amounting to 10 times that of Longtan. For this reason, the plan for Longtan Power Stations provides a relatively good solution to the contradiction of full utilization of water energy and a minimum loss from submergence.

The Datengxia Power Station has a central location. It controls a large area of convenient transportation and good construction conditions. This is the final important stage of the plan. For the normal water level, schemes of 45, 50, 53, and 57 m were considered and a scheme of 75 m was once proposed. Although at 75 m, a reservoir capacity of 3.600 million m^3 may be obtained, the land to be submerged will be 450 thousand mu and 200 thousand inhabitants will have to be relocated (this is a 1959 figure; much larger at present.) The scheme will submerge 2 county seats, the Xiang-Gui [Hunan-Guangxi] Railway, the Heshan Coal Mine, and an important grain producing center of central Guangxi Yulin. For these reasons, this scheme cannot be implemented. With the 45, 50, 53 m schemes, although losses from submergence are reduced, the quality of power production is poor. It cannot be connected satisfactorily with the grades of the upper reaches. The shortcomings appear to be obvious. With the 57 m scheme, the reservoir will basically not exceed the river trough and the area of submergence will not be much larger than the 53 m scheme. When flood control dikes are added in the reservoir area, a portion of the land to be submerged may be saved. The quality of power and the navigation condition may be improved. The machine capacity of that station is 120 Mw. During stepped operation, the guaranteed output is 57.6 Mw, with an annual power production of 70.6 MWh. The total reservoir capacity is 17,600 million m^3, of which 1,000 million m^3 is for flood control. When this is joined with the reserve capacity of 10,000 million m^3 of Longtan for combined regulation, the once every 50 years flood peak of Wuzhou may be weakened from 48,500 m^3/sec to 44,600 m^3/sec. The flood control index of Xunjiang and Xibeijiang Delta may also be raised from the once every 20 years level to the once every 50 years level. For this reason, the plan for Datengxia also handles the relationship between power generation and flood control, navigation well.

In the 10-grade development plan of Hongshui River, aside from grades of Longtan and Datengxia, there are also such major grades as Dahua, Yantan, Tianshengqiao (Fenbasuo, Bapan) etc. as well as the relatively small scale grades of Bailongtan, Wutan, Qiaogong, and Pingpan. Dahua Power Station is currently under construction. The first stage machine capacity is 40 Mw, with another 20 Mw to be added when the regulating reservoir of the upper reaches is completed. The first group of generators is expected to produce power in 1983. It will be the first large scale hydroelectrical power station on Hongshui River. The dam of Yantan is chosen to be in a diabase section, with relatively good geological conditions. It will be one of the backbone power stations in the Hongshui River Project. Its normal water level is 223 m, with a total reservoir capacity of 24,300 million m^3. The machine capacity is 140 Mw. When it is operated independently, 23.1 Mw is guaranteed, with the annual power production of 59.7 MWh. When it is linked with Longtan Power Station of the upper reaches for joint operation, it may guarantee an increase of output of 76.5 Mw to increase the annual power output to 80 MWh. The loss from submergence is not large. At present, the primary design has been completed and is awaiting approval. The Tianshengqiao Power Station is divided into the Bapan high dam and the Basuo low dam (The Survey and Design Academy of Bureau No 9, of the Ministry of Electrical Power is proceeding with the survey and designing process.) The high dam has a normal water level of 780 m; the low dam 645 m. The machine capacities of the 2 stations will be 232 Mw to guarantee an output of 115 MWh, with an annual power production of 135 MWh. The high dam reservoir capacity is 9,000 million m^3; it is provided with a yearly regulating capability.

Judging from the entire cascade development scheme of Hongshui River, all the technical and economic indices are extremely superior. The losses from submergence are not great for either the large reservoirs of good regulating properties or for the low head runoff power stations. Due to the provision of large regulating reservoirs in the upper reaches, the water energy resources can be fully and reasonably utilized. The engineering scales of the various steps vary from several tens of Mw to several hundreds of Mw, which are suitable for the needs of the near future and the long range. The geological condition of the headquarters of the major grades are good, with stable regional structure and not very high earthquake intensity. The problem of seepage of the reservoirs does not exist; the construction and transportation conditions are convenient. The geographic locations are appropriate to provide easy linkage to form power network. With all these favorable factors, the speed of develop-work on the Hongshui River Project will certainly be quickened.

IV. Attention by the Leaders, Support From all Sides, and Good Coordination form the Important Conditions for Implementing the Hongshui River Plan

The work of planning for the comprehensive utilization of Hongshui River proceeded under the direct leadership of the party committee and the government of Guangxi Zhuang Nationality Autonomous Region. Ministries of Water Conservancy and Electrical Power provided support and assistance in many ways. Comrades of the central party and the State Council have consistently been concerned and giving proper attention to the development and utilization of Hongshui River. At the Conference for Examining the Hongshui Project Plan, Vice Premier Yu Qiuli provided important directives regarding the necessity for accelerating hydroelectricity construction, China's energy policy, the policy for Hongshui River development, and ways of hastening the development process of the Hongshui Project. The National Energy Committ and the National Planning Committee have studied the concrete problems relating to the Hongshui Project many times. This indicates a great concern for the masses of the Hongshui River Valley and an encouragement to implement the plan well.

The development and utilization of Hongshui water energy resources involve the requirements and benefits of all the regions and departments. Comrades in charge of the Guangxi Regional Planning Committee, the Regional Construction Committee, Water Conservancy, Electrical Power, Transportation, and Coal have been organized into the Guangxi Water Conservancy Electrical Power Planning Group to proceed with regular discussions of some problems of principle in the plan, to exchange opinions, and to coordinate moves. The Regional Party Committee and the Planning Group members came to the dam sites of all the stages to inspect and to listen to reports. They emphasized repeatedly that the plan should be precise on the important points and at the same time demands of all aspects should be taken into consideration in the overall planning. The water energy resources should be fully and reasonably utilized while as much as possible the losses from submergence should be reduced. All these actions clarified the thinking process of those who directed the planning and reinforced the concept of the interests of the whole. As all sides are thus harmonized and unified, we were able to complete the report successfully within a relatively short period of time.

In these 30 plus years, those who participated in the surveying, planning, and designing of the Hongshui Project included the former Zhujiang Water Conservancy Committee, the Beijing, Guangzhou, Changsha, and Chengdu Design Academies of the Ministry of Electrical Power, and in recent years, the Central South and Northeast and the Bureau No 9 Designing Academies of the Ministry of Electrical Power and the Guangxi Hydroelectrical Power Designing Academy also performed considerable survey and design work on Hongshui River. Furthermore, some geological, hydrological, mapping, transportation, scientific research organizations and institutions of higher education also participated in the investigation and research work for the development and utilization of Hongshui River. They gathered and provided a great deal of information. It may be said that the Hongshui Plan is the crystallization of many years of diligent labor of a vast number of engineers, specialists, workers, and cadres, struggling on the Hongshui River.

Due to the limitation of our experience and knowledge and the shortage of time, there are still shortcomings in the planning work, however. For example, the cascade arrangement of the section from Dahua to Datengxia has not been studied to a proper depth. With respect to some smaller scale cascades, the prospecting work was far from exhaustive and the data were of low precision. The studies on flood control, navigation, irrigation, and marine product requirements were not sufficient. There was very little work performed on estimating the power needs of the region, the plan of the electrical power system, economic analysis, ecological balance, and environmental protection. Of course, with the development of the national economy, the work of stream planning will continue. The aforementioned shortcomings will be continuously supplemented and perfected in the course of future work.

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PUTTING POWER GENERATION FIRST IN DEVELOPMENT OF THE HONGSHUI RIVER

Beijing SHUILI FADIAN [WATER POWER] in Chinese No 4, 12 Apr 82 pp 15-20

[Article by Hydroelectrical Power Division, Planning Department, Ministry of Electrical Power]

[Text] Hongshui River is a "rich mine" of China's water energy resources and an important energy base of South China. The comprehensive utilization plan of that river has been examined at a conference called by the National Energy Committee and the National Planning Committee in Oct 81 (see WATER POWER, No 11, 1981 of this journal). An agreement was reached at the conference that the development policy of Hongshui River should primarily be for power generation, with considerations of such comprehensive utilization as flood control, navigation, irrigation, marine products, etc. This resolution basically corresponds with the 10 cascades development scheme proposed in the Planning Report and the development schedules of the power stations of the various grades were preliminarily arranged. Delegates attending the conference unanimously proposed accelerated development to meet China's needs for socialist modernization construction.

I. Superior National Conditions, Rich Water Energy Resources

Hongshui River originates in the Yunnan-Guizhou Plateau, being a section of the main channel of Xijiang in the Zhujiang Valley. It has the name of Hongshui [Red Water] because of the faintly red color of its water, which, in the upper reaches, flows through the weathered sandy shale strata. The upper reaches are called Nanpanjiang. It flows through Yunnan to the border area of Guizhou and Guangxi to converge with B[illegible]jiang and from that point on it is called Hongshui River. This river e[illegible] Guangxi in Tiane County, passing through the center of the [autonomous] region to join Liujiang at Sanjiangkou of Shilongzhen in Xiangzhou County. This segment is called Qianjiang. The area of Hongshui River Comprehensive Utilization Plan includes Nanpanjiang of the upper reaches, i.e. the section from the entrance of Huangni River to its convergence with Beipanjiang, and the lower reach section from Qianjiang to Datengxia, a total of 1,050 km in length, involving a total drainage area of 190,000 km^2.

This paper was written by Zhu Chengzhang [2612 2052 4545].

Hongshui River has the following characteristics:

(1) The river valley is in the subtropical zone, with mild climate and plentiful rainfall, 1,200 mm in the upper reaches, 1,500-1,800 mm within the boundary of Guangxi. The multi-year average flow volume at Datengxia is 4,200 m^3/sec. The actual measurement of the maximum flood peak reaches 45,700 m^3/sec and the annual water volume reaches 133,000 million m^3, 3 times that of Huanghe in a drainage area of only a 1/4 that.

(2) Due to the fact that the aforementioned sections belong to a transitional zone between the Yunnan-Guizhou Plateau and the hilly plains of South China, the grade differential is extremely concentrated. The elevation of the water surface of Nanpanjiang at the entrance of Huangni River is about 780 m; at the site of Datengxia Dam, the low water level has dropped to 23.5 m. The total differential is as much as 750 m. The section of Nanpanjiang from Tianshengqiao to [illegible] measures only 14.5 and the concentrated drop is 181 m, averaging 12-13 m/km. The local people call this area Leigongtan; it is the most concentrated drop of the entire river.

Beside the above characteristics, both banks are precipitously high mountains to constitute an extremely abundant source of water energy and to provide an excellent condition for generating hydroelectrical power.

II. A Preliminary Development Scheme Selected by Summarizing Experiences and Lessons

On the basis of several previous plans, the Hongshui River Comprehensive Utilization Plan Report is proposed by the Office of the Guangxi Hydroelectrical Power Planning Group and is the fruit of diligent labour of comrades of the departments of electrical power, water conservancy, transportation, etc. of Guangxi Zhuang Nationality Autonomous Region, and the Central South Survey and Design Academy, the Survey and Design Academy of the Bureau of Hydroelectrical Power Engineering No 9, and the Northeast Survey and Design Academy of the Ministry of Electrical Power Industry. That Plan received unanimous praise of the delegates who participated in the examining conference. They regarded it a reasonable and implementable plan.

Ever since the liberation, the rich water energy resources of Hongshui River have received immense attention from the departments of electrical power and water conservancy and four successive plans have been produced. The first two plans (1959 and 1960) overly emphasized flood control in their arrangement of high dams and large reservoirs in the middle and lower reaches. Croplands had to be submerged and a very large population relocated. These plans cannot be carried out. The third plan (1973) again overemphasized medium and low head runoff power stations. It has an arrangement of 12 cascades in the entire river. The cropland to be submerged and the persons to be relocated are greatly reduced but the necessary regulating reservoirs are neglected so are the requirements of reasonable development and comprehensive utilization of water energy resources. The installed capacity and the annual power production are less than half of the previous plans. It also cannot be carried out. The fourth plan (1980) proceeded on the foundation of the large quantity of work performed previously, especially in such matters as the preliminary selection of such good dam sites as Longtan, Yantan, Datengxia, etc. Due to the fact that the development policy of primarily for power generation, with considerations of the comprehensive requirements of flood control, navigation, irrigation, and marine products has been clearly defined and through absorbing the experiences and lessons of previous plans, in this plan, the relationship between the upper and the lower reaches, between the near future and the long range, between needs and possibilities, between engineering benefits and losses from submergence, etc. are; therefore, more satisfactorily handled and the development scheme is more reasonable. For the convenience of comparison, the major indices of these schemes of development for the various cascades are listed in Table 1, the sites of power stations of the various cascades in Fig. 1, and the longitudinal sections of the cascade development scheme in Fig. 2.

Table 1. Major Indices of Four Planning Schemes

	Year			
Time of plan	1959	1960	1973	1980
Number of cascades	7	6	12	10
Total reservoir capacity (100 million m^3)	294.1	545.7	121.4	412.9
Machine Capacity (Mw)	1016.5	1192.5	486.4	1112
Guaranteed output (Mw)	-	-	145.4	549
Annual power production (100 MWh)	508.1	656.5	285.7	603
Cropland to be submerged (10,000 mu)	62.1	74.6	8.5	16.43
Persons to be relocated (10,000 persons)	38.9	42.4	6.9	18.02

Note: It is not entirely reasonable to compare the figures of cropland to be submerged and the population to be relocated because the figures are those of the time of each survey. In these 10-20 years, there has been great increases of population.

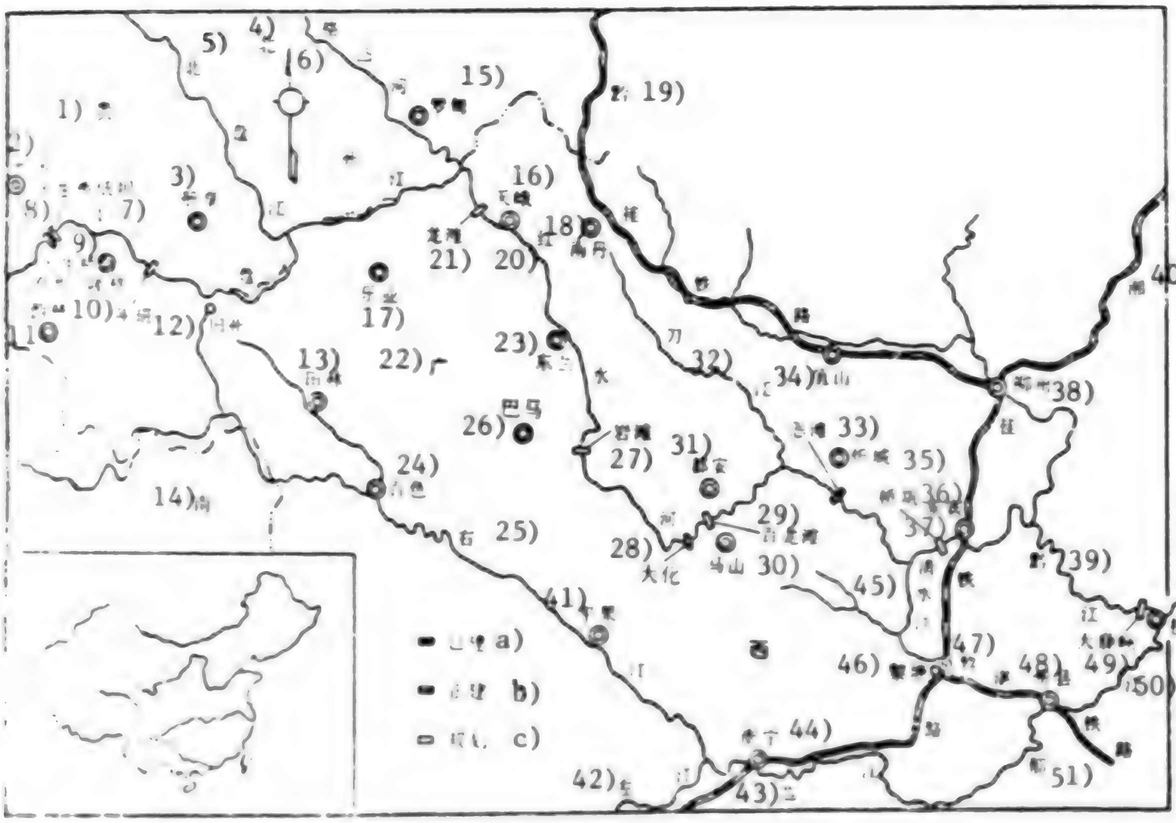

Fig. 1 Map Depicting Sites of Hongshui River Cascaded Hydroelectric Power Stations

1. Guizhou Province
2. Xingyi
3. Ceheng
4. North
5. Beipanjiang
6. Getu River
7. Nanpanjiang
8. Tianshengqiao low dam
9. Tianshengqiao high dam
10. Longlin
11. Xilin
12. Jiuzhou
13. Tianlin
14. Yunnan Province
15. Luodian
16. Tiane
17. Leye
18. Nandan
19. Qian-Gui [Guizhou-Guangxi] Railway
20. Hongshui River
21. Longtan
22. Guangxi Province
23. Donglan
24. Baishe
25. Youjiang
26. Bama
27. Yantan
28. Dahua
29. Bailongtan
30. Mashan
31. Duan
32. Daojiang
33. Wutan
34. Yishan
35. Xincheng
36. Qiaogong
37. Laibin
38. Liuzhou
39. Qianjiang
40. Xiang-Gui [Hunan-Guangsi] Railway
41. Pingguo
42. Zuojiang
43. Yongjiang
44. Nanning
45. Qingshuijiang
46. Litang
47. Li-Zhan Railway
48. Guixian
49. Datengxia
50. Guiping
51. Yujiang

a. has been constructed
b. under construction
c. being planned

The following approaches are adopted in this scheme of selecting the plan:

(1) Based upon the real conditions, in the region of alpine mountains and narrow ravines of the upper reaches, sites of favorable topographical and geological conditions with relatively small losses due to submergence are designated for constructing multi-year regulating reservoirs such as Tianshengqiao, Longtan, etc. to raise the benefits of power generation and comprehensive utilization. In the middle and lower reaches, hills and plains are interspaced. In sectors of mainly limestone strata and a high density of inhabitants, low and medium head cascades are adopted to construct large flow volume riverbed type power stations. Engineering measures of low dam and high lock are also adopted to stay away from unfavorable geological conditions and large amount of loss due to submergence.

(2) As much as possible the various cascades of the upper and lower reaches are made to be closely interlinked so as not to lose head for the maximum utilization of water energy resources.

(3) After the conditions of the dam and reservoir sites are basically clarified, as much as possible, the site of the headquarters are selected in sectors with water barrier conditions, and karst areas are avoided as much as possible.

(4) Benefits of comprehensive utilization, such as flood control, navigation, irrigation, etc. are given appropriate weights in the plan while the requirements of these utilizations are all given overall consideration on the basis of the prinicple of power generation as the major objective.

Through the above approaches, several schemes are compared to arrive at a scheme of 10 grades [cascades] of Tiansnengqiao Bapan High Dam, Tianshengqiao Basuo Low Dam, Pingban, Longtan, Yantan, Dahua, Bailongtan, Wutan, Qiaogong, and Datengxia to cover the entire river (details of technical and economic indices are in Table 7.) Of these, aside from Wutan Hydroelectrical Power Station (First Stage) that is completed and producing electricity, the construction of Dahua Power Station has begun. For the five cascades of Tianshengqiao High Dam, Tianshengqiao Low Dam, Longtan, Yantan, and Datengxia, a great deal of survey and designing work has been performed and the schemes are relatively clarified. The total machine capacity of these six power stations will reach 1,000 Mw, with an annual power production of 50,000 MWh. If all of these are developed and utilized, each year, 30 million tons of coal, that would have been used to generate power, will be saved. The remaining four cascade power stations are of small scale and not much survey and designing work has been done for them. They may have to be adjusted and changed when the desings of the above mentioned cascade power stations are firmly determined.

Judging from the overall plan, the Hongshui River Cascade Hydroelectric Power Stations have the following obvious characteristics:

(1) The regulating property of the reservoirs is good; the power generation benefits are great; the electrical power is of high quality; the economic indices are superior. On the average, the capital investment is only 1,100 yuan per kw of machine capacity, and only 0.2 yuan per kwh of power.

(2) The regional geological structure is stable; the seismic intensity is not high. The dam sites of several major cascade power stations are on sandy shale and lava rocks stratum. Unfavorable geological conditions are avoided.

(3) Loss from submergence by reservoirs is relatively small (see Table 2 for details.) When all 10 cascades are counted together, 272 mu of lands are to be submerged and 300 persons relocated for every 100 MWh of power, only about $\frac{1}{2}$ as great as the large to medium hydroelectrical power stations currently under construction. This small size of loss from submergence is rare.

(4) The geographic location is properly centered. It is relatively near load centers. The power transmission distance is generally several tens to hundreds of km. The farthest distance from Tianshengqiao Power Station to Guangzhou City is only 1,000 km. All are within the economical power transmission distance of 500 Kv alternate, direct power transmission lines.

(5) Medium and large scale power stations are combined with capacities of tens to hundreds of Mw. When the items of construction are appropriately arranged, they may adapt to short term and long range load developments.

Among the Hongshui River Cascade Hydroelectrical Power Stations, the Tianshengqiao High Dam (Bapan) and Longtain power stations have multi-year regulating reservoirs which are key engineering projects of the river development. For Longtan power station, three schemes of normal water levels of 375, 400, 440 m have been studied, with machine capacities of 300, 400, and 600 Mw respectively. The Examining Conference regards the 350 m scheme's relatively poor power generation and comprehensive benefits less than satisfactory, while the loss from submergence of the 440 m scheme much too great and the engineering technique too complex; therefore, the water level of 400 m is assigned for the time being, and a development program of development in stages is being studied.

Datengxia power station is a multi-purpose comprehensive utilization engineering project. Its location is important and benefits are obvious. At present, further investigation and research are needed to decide ways of handling the relationship of such aspects as power generation, flood control, navigation, etc. After repeated negotiations and discussions, the power generation water level is tentatively designated as 57 m (corresponding with the elevation of Hanghai, which is 57.6 m.)

The development condition of Hongshui River Cascade Hydroelectrical Power Stations and the technical, economic indices are extremely superior. They are comparable with the commonly acknowledged "rich mine" of water power of the hydroelectricity basis of the upper reaches of Huanghe. The total machine capacities of these two projects and their total investment costs are not very different, but the former is closer to the power users and the annual power production is also 1/5 higher and the loss from submergence is smaller than the latter.

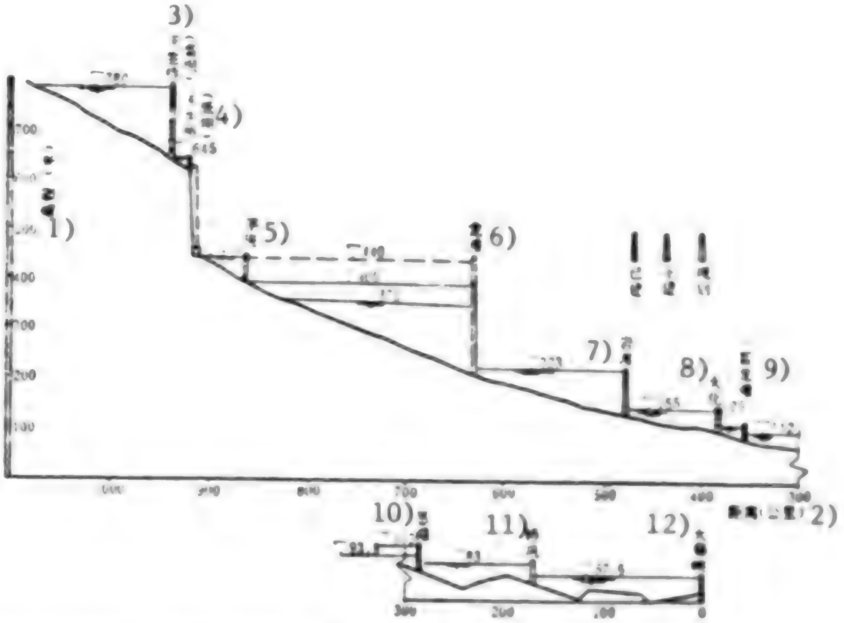

Fig. 2 Longitudinal Section of Hongshui River Cascade Development Scheme

1. elevation (m); 2. distance (km); 3. Tianshengqiao (High Dam); 4. Tianshengqiao (Low Dam); 5. Pingban; 6. Longtan; 7. Yantan; 8. Dahua; 9. Bailongtan; 10. Wutan; 11. Qiaogong; 12. Datengxia.

III. Significant Effects of Hongshui River Development and Utilisation on the Regional Economic Development of South China

Due to the fact that the energy resources of Hongshui River are abundant and the conditions superior, and the fact that an overall policy of primarily for power generation with considerations of comprehensive utilization benefits has be ascertained, after the project is implemented step by step, there will be gigantic positive effects on the economic development of South China.

(1) Power Generation: The power supply area of Hongshui River Cascade Hydroelectrical Power Stations will be the three provinces, region of Guangdong, Guangxi, and Guizhou. Of the three, the water power and coal resources of Guizhou Province are relatively rich. Aside from the Nanpanjiang water power resource which it shares with Guangxi, it also has the rich water power resource of Wujiang. Guangxi has the abundant water energy resource of Hongshui River, but it is

deficient in coal and petroleum resources. Guangdong has few coal reserves and most of the areas having relatively good water energy conditions have already been developed and utilized; therefore, the best way of resolving the problem of power shortage is to develop the water power of Hongshui River. Judging from the power transmission distance, the distance of the various Hongshui River power stations is mostly within 400 km from Guiyang, only 100-200 km from Nanning, with 400 km the farthest. The distance from Guangzhou is only 400 km from the nearest Datengxia; from the farthest Tianshengqiao high and low dams it is no more than 1,000 km. Guizhou and Guangxi have rich resouces of colored metals and phosphate rocks. The rich Pingguo aluminum deposit of Guangxi is less than [illegible] km away from Dahua and Yantan power stations, and only 210 km from the largest scale Longtan power station. Hence, the development of Hongshui River hydroelectricity can make up the deficiency of energy, including electric power of South China and also take on the task of regulating peaks and frequencies of the three provinces.

(2) Flood Control: The major target of flood control of Hongshui River is Xunjiang and the banks of Xijiang as well as improving the flood control standard of the Zhujiang Delta. The Plan Examining Conference, therefore, believes that the policy of primarily releasing, with added consideration of releasing and storing should be implemented. Based upon the principle of considering the upper and lower reaches together, such measures as reinforcing and adding heights to dikes, and panning floodwaters with reservoirs of Zhujiang and upper reaches of the main channel and tributaries of Beijiang to bring about a suitable improvement of the flood control standard are adopted. When the floodwater of the upper reaches of Xijiang is regulated by the Longtan Reservoir, the once every 50 years peak flow volume of Wuzhou may be reduced from 48,500 m^3/sec to 44,000 m^3/sec (to the level of once every 20 years.) This is to say that after the Longtan Reservoir is complete, the flood control standard of Xijiang, Beijiang, and the delta may be raised from the once every 20 years level to the once every 50 years level and the flood control standard of the banks of Xunjiang may also be correspondingly raised.

(3) Navigation: The Hongshui River from the point of convergence of Nanpanjiang and Beipanjiang up is not navigable. From the point of convergence down to the entrance of Liujiang, the 633 km section has many shoals and swift water. Navigation is difficult. The 116 km section from the entrance of Sanjiang to [illegible] relatively good condition for navigation, but the gorge of Datengxia must be closed for a short period every year during the floodwater stage. At present, the cargo volume is not very large. With the complete development of Hongshui River, combined with some local repair of channels, the condition of navigation may be improved, but such matters as the long range cargo volume, the navigation standard, the way of dam passage, etc. are all in need of further study. The contradiction of peak regulation for power generation and the navigation flow at Datengxia should also be resolved through further study.

(4) Irrigation, Marine Products, etc.: The requirements of these comprehensive utilization aspects do not influence the cascade development scheme a great deal. The related departments may continue the studying and planning. All in all, the [illegible] of the development of Hongshui River 's prime objective of power generation will necessarily bring about great benefits to irrigation, marine products, and the tourist industry.

Table 2. Technical, Economic Indices of Hongshui River Step Power Stations

Indices		unit	Tianshengqiao			Pingban
			Bapan [highdam]	Basuo [low dam]		
				first stage	second stage	
drainage area to be controlled		km^2	49906	50194		51650
normal storage water level		m	780	645		440
total reservoir capacity (below normal storage water level)		100 mil.m^3	90	0.26		3.2
drop utilized		m	135	205		40
guaranteed output	independent operation	Mw	42.0	19.0		3.57
	joint opera. of all cascades of river	Mw	42.0	73.0		15.1
machine capacity		Mw	108	80	44	36
average annual power production	independent operation	100 MWh	53.0	47		9.2
	joint opera. of all cascades of river	100 MWh	53.0	82.0		18.6
submergence by reservoir	cropland	mu	27060	140		1606
	population relocation	person	25100	190		1200
maximum height of large dam		m	180	58		61.4
construction volume	dirt & rock excavation	10,000 m^3	1774.7	443	0	312
	rock cavern excavation	10,000 m^3	130.7	251	94	20
	dirt & rock fill	10,000 m^3	2348.7			180
	concrete	10,000 m^3	183.1	180	22	35.5
construction duration		year	10	8		
construction investment		100 million yuan	18.75	6.49	1.91	3.43
investment of machines/kw		yuan/kw	1736	839		953
power transmission construction	to Guangzhou	km	1000	1000		
	to Liuzhou	km	530	530		
	to Pingguo	km	310	310		
	to Nanning	km	410	410		
	to Guiyang	km	400	400		

Longtan	Yantan	Dahua		Bailong-tan	Wutan	Qiao-gong	Dateng-xia	Total
		first stage	second stage					
98500	106500	112200		112500	118000	123500	190400	
[illegible]	223	155		125	112	83	57.6	
274	24.3	3.54					17.6	
[illegible]	68	30		13	29	26	31.4	754.4
153.0	23.1	10.5		3.8	8.0	8.0	22.2	
[illegible]	76.8	35.9		16.1	36.0	31.10	57.6	549.0
[illegible]	140	40	20	18	58	50	120	1112
181.0	59.7	20.6		5.2	24.0	21.8	58.2	
[illegible]	80.0	36.0		9.1	36.2	31.5	70.6	603.0
[illegible]	29156	4294		1150	5880	14100	25687	164267
[illegible]	37565	577		0	1110	2700	47755	180297
[illegible]	104	74.5		22	60	55.6	78.5	
[illegible]	659	760	78	120	394	220	716	
[illegible]		—						
[illegible]	120	111	30	86	30	380	431	
[illegible]	313	130	30	62	105	110	309	
[illegible]	10	10	0				0	
[illegible]	15.11	4.96	1.18	2.55	4.86	4.76	18.04	[illegible]
[illegible]	1170	1020		1417	868	952	1503	1074 (average)
[illegible]	720	540					400	
[illegible]	220	150					120	
[illegible]	80	60						
[illegible]	180	120						
		330						

IV. Assigning Cascade Power Station Development Schedule According to Local Power Needs

The determination of a cascade power station development schedule is based not simply on the quality of its technical, economic indices. It is also determined by the power needs of the local development of the national economy. For this reason, different development schedules have been proposed for the different development schemes at different dates. For example, toward the end of the 50's, the plan recommended the construction of the very last cascade - the first stage of Datengxia. At that time, the high dam (a normal high water level of 75 m) scheme is adopted, having the advantages of good regulating property, good transportation, construction conditions, and close to load centers. Due to the great loss from submergence, the scheme cannot be implemented. In the early 70's, for the purpose of reducing the loss from submergence, the normal high water level for Datengxia is reduced to 45 m to make it into a runoff type, low head power station. Due to the fact that the guaranteed output before the construction of power stations with regulating capabilities is too low and the fact that power generation has to cease during the flood stage, the medium scale Dahua Hydroelectrical Power Station close to the load center is chosen instead for the power needs of Guangxi. That power station is now under construction and is expected to generate power in 1983.

In the most recent plan, it has been considered that after Dahua Hydroelectrical Power Station, Tianshengqiao and Longtan should be first developed. Afterwards, when Longtan, which has regulating capability, is complete, Datengxia may be constructed. Longtan is the key engineering project with the characteristic of controlling the entire river. Once it is developed, the construction and operating conditions of all cascade power stations in the lower reaches may be improved to raise the guaranteed output and the quality of power. Due to the fact that the construction scale of this project (Longtan) is great, requiring a great deal of capital investment and the fact that the construction of the Pingguo aluminum base has been slowed down by the readjustment of the national economy, it was decided that the construction of Longtan and Datengxia should be delayed also.

In view of the above situation, in order to meet the power needs of Guangdong, Guangxi, and Guizhou, it was decided that a project requiring less investment, occupying little land, showing benefits fast, having a scale of construction corresponding with the speed of growth of power needs, and technically easy to construct should be developed first, and it should be coordinated with construction of key reservoirs capable of regulation, to gradually bring about the benefit of cascade development. Hence, the plan proposes to construct the Tianshengqiao Low Dam Hydroelectrical Power Station first. That station has the advantages of simple engineering, little investment, short construction duration, fast benefits, and small loss from submergence. It also may be constructed in stages. In the first stage, by constructing one low dam and two water drawing tunnels measuring 11.3 km in length and 9 m in diameter each, a drop of 205 m may be obtained. With machine capacity of 80 Mw, the annual power production is 4,700 MWh. Tianshengqiao low dam and high dam are a group of inseparable projects. When the low dam is completed, using the cofferdam to store water, the guaranteed output of the low dam power station may be gradually raised. When the high dam is about to be completed, one more tunnel and two machine groups may be added onto the low dam station to cause its total capacity to reach 124 Mw, an annual power production of 8,200 MWh, and a guaranteed output of 73 Mw.

The Tianshengqiao High Dam is one of the key engineering projects of Hongshui River development. Its main body is an earth and stone dam of 180 m in height and the plant behind the dam. The total reservoir capacity is 9,000 million m^3 and it is capable of multi-year regulation. The power station machine capacity is 108 Mw, with a guaranteed output of 42 Mw and an annual power production of 5,300 MWh. Further more, it may also increase 87 Mw of guaranteed output of the three stations of Tianshengqiao Low Dam, Yantan, and Dahua below it. The increased annual power production of the low dam will be 3,700 MWh. The benefits are very obvious.

The geological condition of Yantan Hydroelectrical Power Station is rather good, its construction is relatively simple, mainly a concrete dam 108 m in height and the plant. The machine capacity is 140 Mw. In cascaded operation, its guaranteed output is 77 Mw and the annual power production is 8,000 MWh.

Longtan and Datengxia should be constructed after the construction of the aforementioned three power stations has begun and if the power needs warrant it. With respect to the remaining several small scale power stations, they should also be constructed at a proper time. These power stations may produce power gradually in the period between the 7th 5-year plan to the 10th 5-year plan. It is estimated that all will be operative in the years 2000-2005. By that time, Guangdong, Guangxi, and Guizhou may be connected into an ultrahigh voltage transmission network. The power of Hongshui River will be delivered to the industries, mines, cities, and rural villages of the three province (region) without interruption.

In order to accelerate the development process of Hongshui River, the Ministry of Electrical Power Industry has made arrangements to increase the survey, designing, and construction capabilities. At present, the preliminary designs of Tianshengqiao High Dam, Yantan, Longtan, and Datengxia are being rushed. The leadership organization, the raising of the investment capital, and related economic policies regarding Hongshui River Projects are being studied. We believe, under the joint efforts of the three provinces (region) and related ministries and committees, the idea of accelerating the construction of Hongshui River Cascade Hydroelectrical Power Stations will become a reality soon.

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DEVELOPMENT OF THE HONGSHUI RIVER CASCADE PROJECTS

Beijing SHUILI FADIAN [WATER POWER] in Chinese No 4, 12 Apr 82 pp 21-27

[Article by Cai Yaozhong [5591 3852 1813]: "Investigation Concerning the Development Procedure of Hongshui River Cascade Hydroelectric Power Stations"]

The cascades of development scheme and the selection of a development sequence form the 2 great tasks of a river valley planning. It is a strategic overall problem. How well these 2 tasks are handled will affect the successful development of the entire river valley and will determine whether or not there will be sizable benefits of comprehensive utilization. Repeated studies are;therefore, necessary in order to arrive at a policy cautiously.

Through more than 20 years of joint efforts of related provinces, regions, and departments and after 3 comparisons of difference schemes, a development scheme of 10 cascades or terraced steps was finally found to construct regulating reservoirs in the upper reaches and medium to low head cascades in the middle and lower reaches to bring about relatively good economic benefits and to avoid large losses from submergence. Aside from individual problems, this scheme has been basically finalized. The machine capacity is to be 1,100 Mw with an annual power output of 600 MWh. The resources condition of Hongshui River are superior and the locations appropriate; therefore, the river is known to be China's "rich mine" of water power. It is listed as one of the important energy bases of the nation and should be quickly developed and utilized.

At present, the Wutan Hydroelectrical Power Station on Hongshui River, with navigation facilities and 6 Mw generators, has been in operation since last year. The Dahua Hydroelectrical Power Station is under construction in a tight schedule and is planned to be operative next year. Which stations are to follow Dahua and what is the development program of these cascades? This is a question that everyone is concerned about. It contains mainly 2 problems: The first problem is whether the Tianshengqiao second stage (the low dam), or Yantan, or Datengxia should immediately follow Dahua. The second problem is that among the large reservoirs of the upper reaches, whether the Tianshengqiao First stage (the high dam) should be the first or Longtan should be the first to be developed. Moreover, what are the problems to be considered and what principles to follow with respect to the cascade development procedure. This paper attempts to discuss the 3 problems. Aside from a general discussion of the development program of regulating reservoirs of the upper reaches, the attempt is mainly to use the method of economic analysis to proceed with concrete verification of several [illegible] development schemes centering on the regulating reservoirs, using techniques of minimum present worth and the rate of internal returns.

II. Principle of Hongshui River Cascade Development Procedure

Premier Zhao Ziyang pointed out in his report of government work at the Fifth Session of the Fourth Congress of People's Representatives that "Employing all available means to raise the economic benefits of all realms of production, construction, and circulation. This is a nuclear problem." "From now on, when we consider all economic problems, we must place the basic starting point on raising the economic benefits so that our country's economy will have a sustained good development." These words of Premier Zhao should be the guiding principle in our study on the Hongshui River cascade development procedure. That is the same as the principle of maximum benefit for the national economy, of which we spoke often in the past. Based upon this principle and through technical and economic analysis and comparison, the most superior scheme is selected. Aside from this general guiding principle, based upon the concrete conditions of Hongshui River, the following should also be considered:

(1) The Hongshui River development policy is as follows: It is primarily for generating electricity, with further considerations of such comprehensive utilizations as flood control, navigation, irrigation, and marine products. For this reason, the study on the cascade development procedure should start with the power needs of South China and Guizhou Power systems. The requirements of flood control, navigation, etc. should also be seriously considered, as facts have proved that only by concretely implementing the principle of comprehensive utilization, can the investment cost be reasonably shared in order to reap the maximum benefits for the national economy and to promote the [illegible] of construction.

(2) In the South China System, hydroelectrical power takes on a relatively large share, while the existing hydroelectrical stations and those under construction are mostly poor in their regulating properties. It is, therefore, necessary to build [illegible] regulating reservoir as soon as possible. This is the key to the [illegible] development program. It is also necessary to place in service a group of thermal power generators. By realizing "mutual supplementation of water and thermal, [illegible] they aid one another," the economic benefits of the entire electrical power system may be raised.

(3) The shortage of investment capital is a serious problem of China's economic construction, especially during the 6th Five-Year Plan. In the course of arranging the cascade development procedure, those requiring relatively less capital [illegible], quicker to show benefits, and of properly medium scale should, therefore, be first developed.

(4) [illegible] has a large population and very little land. The contradiction is [illegible]. In the course of studying the development procedure, attention should be carefully given to the problem of losses by submergence. As much as possible the area to be submerged should be reduced and submergence of [illegible] should be delayed. The work of relocating the inhabitants should also be [illegible] well.

The above principles should be concretely analyzed, in terms of engineering, schematic, and especially economic analyses. The principles and the concrete facts should be fused into one entity to become mutually sustaining.

II. Economic Reasonableness of the Scheme of Developing Tianshengqiao Second Stage First, After the Completion of Dahua

On Hongshui River, aside from the existing Wutan and the Dahua that is under construction, the other 8 steps or cascades may be divided into 3 classes according to their scale and characteristics. The first class is the key stage, having regulating reservoirs; this includes Longtan and Tianshengqiao First Stage. The characteristics of this class is the gigantic engineering volume, the long construction time, and the large investment capital, but the benefits are also very obvious. The second class is power stations of about 100 Mw capacities, including the Tianshengqiao Second Stage, Yantan, and Datengxia. The characteristic is relatively poor regulating capability but the scale is appropriately medium with possibility of adapting to load demands. They may be operative in about 1990. The third class is the low head runoff type power stations of about 50 Mw capacity, including the 3 cascades of Pingban, Bailongtan, and [illegible], and possible enlargement of Wutan. The characteristics are the lack of regulation, poor energy economic index, and inability to satisfy power needs of the users. Besides, the preparation work for these is hardly done. If the power needs of the system, especially the region of Guangdong, the power station to be constructed after Dahua, should obviously be a selection among the second class ones, according to the principles discussed previously. The third class power stations should be developed after the regulating reservoirs of the upper reaches are completed, or at least one of them is completed. Longtan Power Station of the first class requires large investment and long construction period. Even if the work can start in 1985, it will be 1997 before power can be produced. It is not suitable for development in the near future. Regarding the Tianshengqiao First Stage, the engineering volume, the investment, and the construction duration are basically the same as Yantan or Datengxia of the second class, i.e. in between the first and the second classes, but its benefits are much greater than Yantan, etc. Logically, it should be included in the comparative study for selecting a target of development in the near future. Not much preparation work has been done, however, and the preliminary design cannot be prepared before 1984. If construction begins in 1985, it will not produce power until 1993. It should, therefore, be pushed back and be studied with the Tianshengqiao Second Stage as one group of power stations in determining the construction schedule. It should be compared with Longtan as power stations of the upper stage with regulating reservoirs.

For the convenience of analysis, the engineering volume, the investment, and the loss from submergence of the 3 power stations of the second class are listed in Table 2.

The date of completion of construction and yearly energy index as listed in Table 2:

Analyses of the following 4 aspects may reveal the advantages and shortcomings of the 3 power stations:

1. Construction condition and the date of power production : The geological

[illegible] of Yantan is the best. The construction condition of Datengxia is [illegible] favorable, but its designing work began rather late. Further investigation and verification are needed to determine the ways of handling the relationship of such aspects as power generation, flood control, navigation, etc. in the engineering plan. The primary design report can be completed no sooner [illegible]. If the construction begins in 1985 and cofferdam may be used to [illegible] the water, the plant of the left bank will be able to produce electricity [illegible]. In this manner, the first group of generators cannot operate until [illegible]. With Yantan, if construction begins next year, power generation is estimated to [illegible] in 1990. The condition of transportation with the outside areas is relatively poor in Tianshengqiao Second Stage but its primary design has long been finished and approved. Due to the fact that the engineering phase is relatively simple, if the work is resumed in 1982, it is possible to be producing [illegible]. In so far as the serious power shortage problem of Guangdong is concerned, this is an extremely significant factor.

[illegible] Capital Investment: As indicated in Table 1, the construction cost is the lowest for Tianshengqiao Second Stage, Yantan is the next, and Datengxia is the highest. In terms of the cost for power transmission and conversion it is [illegible] reversed situation but in different ratios. The sum of capital investment for construction and power transmission, etc. remains to be the lowest for Tianshengqiao and the highest for Datengxia.

[illegible] benefit and quality of power supply: As indicated in Table 2, Yantan is the best in these aspects. Its annual power production and guaranteed output are the highest, even when the increase after regulation by Yantan Reservoir and the 5.7 Mw of Wutan are not included. Further more, Yantan has [illegible] reservoir, which can adjust the peaks and take on the task of furnishing reserve volume in case of accidents, etc. The energy capacity of Tianshengqiao Second Stage is also rather good and its volume during flood stage [illegible] stable. As described in Fig 1, the machines can be fully operative [illegible] months a year to produce 80 Mw. Besides, the power station can adjust [illegible] take on reserve load capacity. In either the matter of quantity or quality, Datengxia has its weaknesses mainly because during dry season, there [illegible] of no less than 700 m³/sec of flow volume due to navigation so that the power station can only operate on the basic load. Basically, it cannot adjust peaks and has only 20 Mw of substitute volume. In the high water stage, [illegible] rising water level of the lower reaches, the reservoir operates at [illegible] control level and the head is lowered greatly to cause obstructions [illegible] output. In a good year, the head will be excessively low for [illegible] days to cause the power station to stop operating for short periods of [illegible] Fig. 1 for details.) This fact causes it to be in a sharp contrast [illegible] compared with Tianshengqiao Second Stage. This situation of low [illegible] in both high and low water seasons is difficult to improve before [illegible] reservoirs are constructed in the upper reaches. Although the plant of [illegible] operative 3 years earlier, the machines are only for 60 Mw. [illegible] water level of cofferdam is limited at 40.5 m, 7.4 m lower than the normal [illegible] water level to cause the annual power production and guaranteed output [illegible].

[illegible] inundation by reservoirs: For Tianshengqiao Second Stage, [illegible] inundation is only 140 m of cropland and 190 persons are to be relocation. The losses for Yantan and Datengxia are similar, but in case of Datengxia, close to 50 thousand people must be moved. The relocation work requires some serious efforts.

The above are analysed on the basis of independent operation of each of these power stations. When the large reservoris of the upper reaches are completed, as the data of Table 1 indicate, the effect of guaranteed output for the power stations of the lower reaches is very great. If Tianshengqiao First Stage is constructed first, the scheme is the most beneficial for Tianshengqiao Second Stage and next for Yantan. This is due to the fact that Tianshengqiao Second Stage has the highest head. The Tianshengqiao First and Second Stages form a group of stations with coordinated reservoirs and head for mutual benefit to become inseparable. If Longtan Reservoir is constructed first, it is the best scheme for Yantan, and next for Datengxia. Tianshengqiao second stage is located above Longtan and its benefit will not be increased. The problem of development schedules for the reservoirs of the upper reaches will be discussed later in the paper.

To summarize the above discussions, we observe that Tianshengqiao Second Stage has the advantages of early power production, low capital investment, stable output during flood stage, and very little loss due to submergence; especially if among the large reservoirs of the upper reaches the Tianshengqiao First Stage is to be constructed first these advantages would be even more outstanding. The distance of power delivery is far and the transportation is inconvenient. Attention should be given to these shortcomings, but generally speaking, they are not essential and they have in fact been reflected in the cost estimate and the duration of construction. Concrete economic computation is, therefore, not necessary before Tianshengqiao Second Stage can be definitely recommended as the preferred first project. As far as a comparison between Yantan and Datengxia is concerned, the two are not very different regarding the power production date, capital investment, and loss due to submergence. The main difference is in the fact that the quantity and quality of power supply, especially in the ratio of replacement volume of Datengxia are very much inferior; therefore, Datengxia should be arranged after Yantan.

1) 2)	3) [illegible]		6) [illegible]		9) [illegible]			13) [illegible]		
	4)	5)	7)	8)	10)	11)	12)	14	15	16
17) [illegible]	[illegible] 20)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	18	23	[illegible]
18) [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	15.2	[illegible]
19) [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	18.04	[illegible]	20.81	[illegible]	[illegible]	[illegible]

Table 1

1. power station; 2. item; 3. construction volume (10,000 m^3); 4. dirt and rock excavation and refill; 5. concrete; 6. submergence by reservoir; 7. cropland (mu); 8. population to be relocated (persons); 9. capital investment (100 million yuan); 10. for construction; 11. for transmission and conversion of power; 12. total; 13. guaranteed output (Mw); 14. independent operation; 15. with Tian-

ngqiao First Stage; 16. with one reservoir of Longtan only; 17. Tiansengqiao Second Stage (first phase); 18. Yantan; 19. Datengxia; 20. including rock cavern excavation of ...)

1) 表2 红水河梯级电站

2) 电站	3) 项目 4) 年份	1981	82	83	84	85	86	87	88	89	90	91	92	93	94	95
9) 天生桥二级（一期）	5) 进度	1978年已完成初设 12)							(2×▲20)(2×20)							
	6) 保证出力								19	19	19	19	19	19	19	19
	7) 工作出力								34.5	35.7	36.8	38	38	38	38	38
	8) 年电量								10	34	47	47	47	47	47	47
10) 岩滩	5) 进度	1982年完成初设 13)										(2×▲35)(2×35)				
	6) 保证出力											23.1	23.1	23.1	23.1	23.1
	7) 工作出力											44.8	44.8	44.8	44.8	44.8
	8) 年电量											13.1	47.3	59.7	59.7	59.7
11) 大藤峡	5) 进度	1984年提出初设 14)								(2×▲15)	(2×15)			(2×▲15)	(2×15)	
	6) 保证出力										16	16	16	22.2	22.2	22.2
	7) 工作出力										16~21	16~21	16~21	22.2~29	22.2~29	22.2~29
	8) 年电量										8.3	27	32.7	36	33	[illegible]

15) 注：▲ 表示第一台机组投产时间。

Table 2

1. Unit: output (Mw) power volume (100 MWh);
2. power station; 3. item; 4 year; 5. rate of progress; 6. guaranteed output; 7. operation output; 8. annual power production; 9. Tianshengqiao Second Stage (first phase); 10. Yantan; 11. Datengxia; 12. primary design has been completed in 1978; 13. primary design will be completed in 1982; 14. primary design to be proposed in 1984. 15. Note: indicates the time when the first generator group begins to operate.

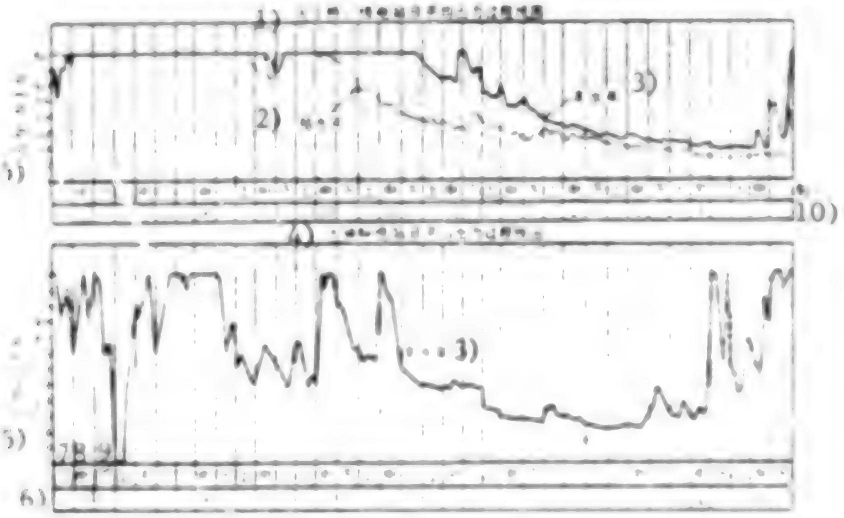


fig. 1

Graph of Daily Average Output of Tianshengqiao Second Stage and Datengxia Power Stations

1. graph of average daily output of Tianshengqiao Power Station; 2. dry year; 3. wet year; 4. graph of average daily output of Datengxia Power Station; 5. output (Mw); 6. month; 7. first 10-day period; 8. middle 10-day period; 9. last 10-day period. 10 10-day period.

III. Development Schedules of Upper Reach Reservoirs Compared

In order to increase the benefits of Hongshui River development, it is necessary to construct the large regulating reservors of the upper reaches in a timely manner. Once these are built, the construction of the power stations of remaining cascades will follow. In order to coordinate load development, in some years it will be necessary to construct two to three power stations simultaneously. Hence, a comparison of the development schedules of the large reservoirs of the upper reaches involves, in reality, the problem of grouping and comparison of the development schedules of all the cascades, centering upon that of the large reservoirs. Three relatively representative shemes are hereby studied. Under the condition of equivalent power production year after year, the total cost outlay and the rate of internal return are computed for selecting the optimal scheme. The major problems involved in the computation are discussed in the following:

(1) Working out a scheme:

The principles for working out a scheme are as follows:

1. The grouping and date of operation of the various power stations of Hongshui River should generally meet the load requirements from year to year. When the load requirement is not met, the shortage must be resolved by the operation of thermal generator groups. The initial estimate indicates that before the year 2005, i.e. with 25 years, the development of Hongshui Project may basically be achieved.
2. Aside from Dahua Power Station, which is operational in 1983, in all schemes, Tianshengqiao Second Stage is assumed to be the first target of construction. The 3 medium sized power stations, such as Qiaogong and the expansion of [illegible] are for the time being not included in the considerations. Thus, among the 10 cascades, only the 6 major ones are included in the computation, of which four participate in the grouping process and they are Tianshengqiao First Stage, Longtan, Yantan, and Datengxia.

Based upon these principles, 3 development schedules are worked out and listed in Table 3. In Scheme I, the yearly capital investment and the energy benefit of the various power stations are also listed to provide a general understanding of these stations and their mutual relationships. It is necessary to explain that the rate of progress of the construction process, the capital investment, and the power production arrangement of the various development schemes are only opinions derived from studies in the planning period. These opinions are offered for the purpose of providing some concrete ideas so that these schemes may be compared. As the planning and designing work proceeds further in the future and as the national economy progresses, the items described in Table 3, such as rate of construction progress, capital investment, etc. will be in need of continuous revision and improvement.

Characteristics of the various schemes are as follows:

Scheme I: Among the upper reach reservoirs, Tianshengqiao First Stage will be developed first and by 1995 Tianshengqiao 1st, 2nd, and Yantan will be completed. The construction of Longtan is considered to begin in 1988 so as to begin to be operational in the year 2000. After production begins, the load requirements may be met in 4-5 years. Datengxia is arranged to begin operation in 1997; if not, more thermal power will be needed to supplement.

Scheme II: Among upper reach reservoirs, Longtan should be the first to develop. Tianshengqiao First Stage will not be in production until 5 years after Longtan produces power. Due to the fact that the duration of construction of Longtan is relatively longer, a scheme of storing water in stages to start producing power earlier had been considered, but the expected output of the first stage turbines would be very low and the benefits would be poor. If the hydraulic turbine is replaced with rotors, the time of completion would be too close to that of the second stage to make the scheme seem to be unreasonable economically and in terms of equipment utilization. For these reasons, the consideration in this scheme is to construct Longtan without deviding into stages.

Scheme III: Among upper reach reservoirs, Longtan is to be constructed first, but it is to be developed in two stages. The first stage begins in 1985 and it will begin to produce power in 1993, with an effective reservoir capacity of [illegible] million, about the same as Tianshengqiao First Stage. There will be an interval of 4-5 years between the first and the second stages, with hydraulic turbine replacing rotors. It is estimated that the capital investment will be [illegible] percent greater if Longtan is to be constructed in two stages.

[illegible] Computation of energy indices

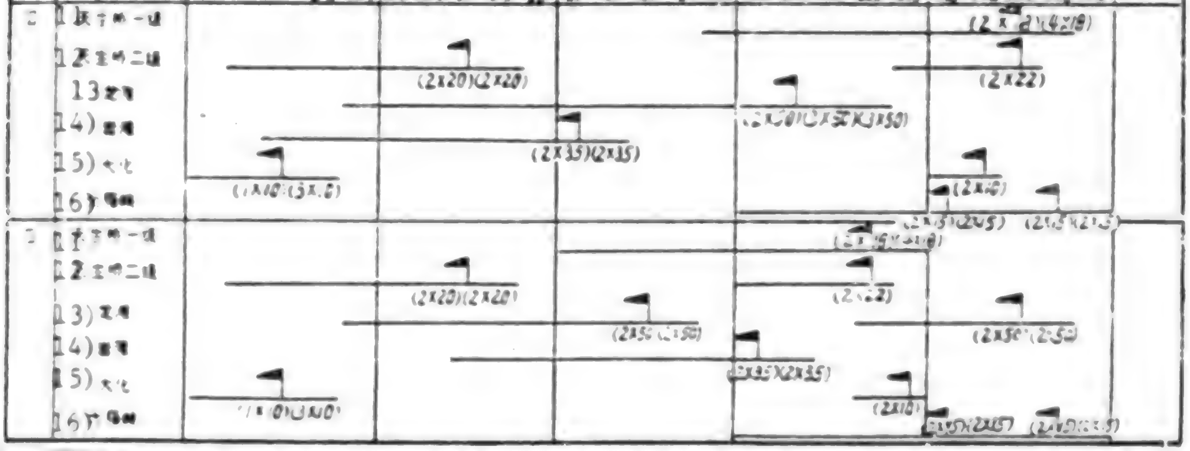
The guaranteed output and annual power production of the various power stations in the various schemes must be computed first. Considerations are given, in the course of computation, to the effects on the low reach cascades during the water storage period of the upper reach reservoirs and during the period of normal operation, and the effects of the initial period of machine installation on the power production.

Computation includes the operation volume of the hydroelectrical power station cascade of Hongshui River. Before the large reservoirs on the Hongshui are completed, only daily regulation cycles are considered. After their completion, seasonal and yearly regulations are taken into consideration to proceed with balancing the annual power volume in order to obtain the operation volume. The operation volume of the power stations is, for the time being, distributed according to the guaranteed output. Factors, such as a portion of the power cannot be utilized during the flood stage, are taken into consideration in computing the annual power volume of Hongshui River; therefore, the design volume is discounted [illegible] percent before balancing.

For thermal power volume, the portion of needed thermal power supplement after the completion of Tianshengqiao Second Stage in 1988 is the only portion that is taken into consideration. Only the portion of the annual difference in the thermal power is computed. The related results are summarized in each of the 5-year plans and included in Table 4, from which the distribution condition of the indices of energy economics of all the schemes may be observed.

1) 表 3　　单位：K（亿元），N（万千瓦），E（亿度）。

2) 方案		3) 项目 / 4) 年份	5) “六五”					6) “七五”					7) “八五”					8) “九五”					9) “十五”					10) 合计
			81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	2000	01	02	03	04	05	
一	11) 天生桥一级	K					0.95	1.25	1.58	2.17	2.82	2.49	1.86	1.89	2.1	1.68												18.75
															(2×18)(2×18)													
		N保													24	30	42	42	42	42	42	42	42	42	42	42	42	42
		E 18)													8.8	29.1	53	53	53	53	53	53	53	53	53	53	53	53
	12) 天生桥二级	K		[illegible]	0.355	1.89	1.65	1.84	2	1.52	2.2	0.9	0.2	0.2														10.4
									(2×20)(2×20)					(2×22)														
		N保								19	26.9	26.9	31.8	42.7	53.6	73	73	73	73	73	73	73	73	73	73	73	73	73
		E 18)								10	34	47	47	51	65	65	82	82	82	82	82	82	82	82	82	82	82	82
	13) 龙滩	K								0.35	0.44	0.92	2.43	3.23	3.8	3.63	2.69	2.37	2.43	2.86	3.0	3.2	1.52	1.58				35.9
																						(2×50)(3×50)(3×50)						
		N保																				75	118	118	165.4	165.4	165.4	165.4
		E 18)																				26.3	103	134	166	185	185	185
	14) 岩滩	K			0.34	1.42	1.52	1.78	1.49	1.56	2.97	2.59	1.24	0.41														15.11
													(2×35)(2×35)															
		N保											25.6	26.5	30.1	33.5	37.5	37.5	37.5	37.5	37.5	37.5	55.7	55.7	76.8	76.8	76.8	76.8
		E 18)											13.1	47.3	59.7	65.3	70.8	70.8	70.8	70.8	70.8	70.8	75.8	75.8	80	80	80	80
	15) 大化	K	3.25	0.55	0.75	0.35												0.66	[illegible]									6.12
					(1×10)(3×10)													(2×10)										
		N保			10	10.5	10.5	10.5	10.5	10.5	12	12	14.5	16.9	17.7	18.4	21.6	21.6	21.6	21.6	21.6	24.6	25.9	25.9	25.9	35.9	35.9	35.9
		E 18)			4	15.3	22.6	22.6	22.6	22.6	22.6	22.6	22.6	22.3	22.3	24.2	26.2	26.2	26.2	30	30	30	33	33	36	36	36	36
	16) 大藤峡	K												0.33	1.41	2.1	2.7	3.33	1.64	2.11	2.0	[illegible]	1.49					18.04
																		(2×15)(2×15)			(2×15)	(2×15)						
		N保																	22.5	22.5	22.5	32.6	42.6	42.6	57.6	57.6	57.6	57.6
		E 18)																	7.8	27	33	39	58	64	70.6	70.6	70.6	70.6
	17) 梯级合计	K 19)	3.25	0.8	1.64	3.22	4.12	4.87	4.68	5.2	7.0	6.77	6.03	7.06	7.31	7.14	5.39	6.96	4.57	5.8	5.81	6.05	2.91	1.48				104.32
		K输		0.2	0.66	0.56	1.2	1.64	1.62	2.38	1.3	1.76	1.87	1.41	1.18	0.5	1.6	1.5	2.4	2.4	2	1.6						27.4
		N装 20)			10	40	40	40	40	80	120	120	190	304	346	412	412	412	462	492	492	622	802	952	952	952	952	952
		N保 18)			10	10.5	10.5	10.5	10.5	29.5	38.9	38.9	72.9	75.3	119.5	135.6	174.1	174.1	196.6	259.6	266.6	281.7	351.2	357.2	430.7	450.7	450.7	450.7
		N工			10	28.3	20.6	21	21.5	54.2	70.2	71.5	120	125	178	207	280	281	321	328	336	448	550	557	672	690	705	705
		E			4	15.3	22.6	22.6	20.6	31	55	68	81	121	198	184	232	232	240	263	269	275	405	442	506	509	529	536



注：K—电站投资，K输—输电线投资，N装—电站装机容量，N保—电站保证出力，N工—电站工作出力，E—电站多年平均 21) 发电量，⚑—第一台机组投产日期。

Table 3

1. Unit: K (100 million yuan), N (Mw), E (100 MWh); 2. Scheme; 3. item; 4. year; 5. 6th 5-year plan; 6. 7th 5-year plan; 7. 8th 5-year plan; 8. 9th 5-year plan; 9. 10th 5-year plan; 10. total; 11. Tianshengqiao First Stage; 12. Tianshengqiao Second Stage; 13. Longtan; 14. Yantan; 15. Dahua; 16. Datengxia; 17. sum of cascades; 18. guaranteed; 19. transmission; 20. installation; 21. Note: K-power station investment; $K_{transmission}$-investment of power transmission lines; $N_{installation}$- power station machine installation volume; $N_{guaranteed}$- power station guaranteed output; $N_{?}$- power station operation output; E - power station multi-year average power production; ⚑ -date of production of first generator group.

3) Flood control benefit estimate of Longtan:

The banks of Xunjiang and the delta region of Xibeijiang are densely populated. The economy is relatively well developed and large and medium sized cities with concentrations of industries, such as Guangzhou, Wuzhou, Fushan, etc. are located there. In the course of studying the cascade development schedules; therefore, the flood control needs of the lower reaches and the benefits should be added and be reflected in the economic computation.

According to the analysis of data of related departments, at present the flood control capabilities of dikes of the banks of Xunjian and the delta region of Zhujiang are rated at /the flood level of/ once every 5 years and once every 10-20 years. Assuming in 10-20 years when Longtan is completed, all the dikes may reach the flood control standard of withstanding the flood level of once every 20 years, through computation of flood regulation capability of Longtan, its flood control result may be considered to be raising the standard from flood level of once every 20 years to that of once every 50 years. The equivalent annual benefit will thus be 10.9 million yuan. (See Fig. 2 for details.)

Out of the expenditures, beginning with the year of completion of Longtan this portion of benefit is, therefore, deducted in the economic computation of the development schedules, year by year. (For the time being, the navigation benefit has not been taken into consideration.)

1) 表 4 [illegible](万千瓦)、[illegible]、[illegible](亿元)。

2)	3) 4)	5) “六五” 1981~85	6) “七五” 86~90	7) “八五” 91~95	8) “九五” 96~2000	9) “十五” 01~[illegible]	10)
[illegible]	11)	20.6	71.5	280.3	448	701	
	12)	36.0	174.6	696	1150	2132	4188.6
	13)		20	20	80	76	196
	14)				82		82
	15)	12.63	28.52	33.19	25.59	4.39	104.32
	16)	2.74	8.2	6.56	9.9		27.4
[illegible]	11)	20.6	57.2	107	43[illegible]	701	
	12)	36	174.6	521	1034	1813	[illegible]
	13)		40	120	40		200
	14)			171	197	319	687
	15)	12.03	25.95	17.4	31.88	17.06	104.32
	16)	2.74	5.88	7.08	8.02	3.88	27.6
[illegible]	11)	20.6	57.2	186	479	[illegible]	
	12)	36	174.6	483	1105	1881	3680
	13)		40	60	30	100	230
	14)			214	109	265	588
	15)	9.9	23.43	26.45	29.57	14.97	104.32
	16)	2.74	1.96	7.58	[illegible]	[illegible]	[illegible]

Table 4

1. Unit: output (Mw), power volume (100 MWh); investment (100 million yuan.) 2. Scheme; 3. item; 4. year; 5. 6th 5-year plan; 6. 7th 5-year plan; 7. 8th 5-year plan; 8. 9th 5-year plan; 9. 10th 5-year plan; 10. total; 11. year-end Hongshui River operation output; 12. Hongshui River total power volume; 13. year-end thermal power supplement volume; 14. thermal power volume differential; 15. total Hongshui River investment; 16. total transmission line investment.

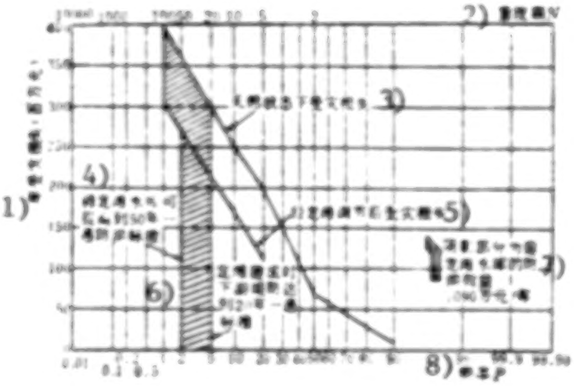


Fig. 2 Graph demonstrating loss from flood damage of lower reaches of Hongshui River and frequency relationship

1. annual loss from damage (million yuan); 2. period of recurrence; 3. damage from loss under the natural condition; 4. completion of Longtan Reservoir raising the flood control standard to once every 50 years; 5. loss from damage after regulation by Longtan; 6. at the time of completion of Longtan, dikes of lower reaches reaching the standard of once every 20 years; 7. Shaded portion is the flood control benefit at the completion of Longtan Reservoir - 10.9 million yuan/year; 8. frequency.

(4) Economic analysis and selection of scheme

The two methods of minimum present worth (PW) and internal rate of return (IRR) are adopted for computation, under the following conditions: Starting with the year of 1981, the total process of computation is for 70 years. Of these years, the first 20 years are mainly a period of construction of all the power plants and a portion of these operational. The next 50 years is a period of normal operation to be analyzed. With regard to investment, the annual expenditure and fuel cost are all converted to the present worth of the beginning of 1981. For thermal power with coal as the fuel, the single machine capacity is considered to be 20-30 Mw, with an investment cost of about 700-800 yuan/kw (sulfur removal installation is not considered.) If coal mine investment is calculated to be about 1,180 yuan, at the time of coal mine construction, the standard price of coal is counted as 60 yuan/ton; after adding transportation cost, the cost of coal is about .039 yuan. The construction investment for thermal power plant is figured at 800 yuan/kw. Moreover, taking into consideration the increasing difficulty of mining coal and the gradual reduction of coal resources, a 1 percent rate of increase is added to the price of coal. For the time being, the method of sharing investment cost of Longtan among the beneficiaries of the comprehensive utilization situation is not considered. Results of computation based upon these conditions are included in Table 5 and Fig. 3.

表 5 1) （单位：亿元）

3) 贴现率 2) 方案	5	8	10	12	14	20
I	100.61	69.53	56.08	46.05	38.61	24.89
II	106.76	73.09	57.93	47.13	38.72	23.85
III	109.10	72.86	57.52	46.42	38.15	23.24
4) 最小现值方案	I	I	I	I	III	III

Table 5

1. Unit: 100 million yuan; 2. Scheme; 3. discount rate; 4. mininum present worth scheme.

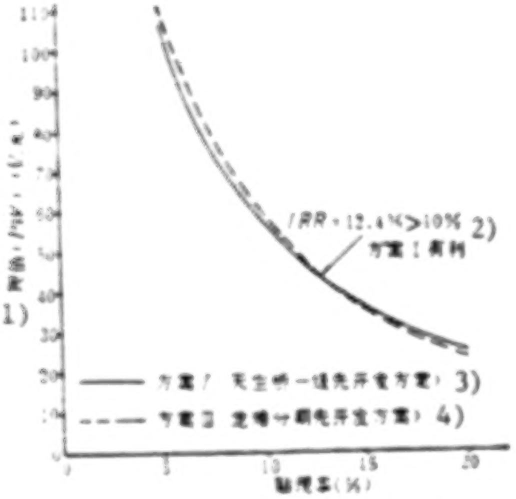


Fig. 3 Economic Computation of Hongshui River Development Schedule Schemes

5) 图 3 红水河开发程序方案经济计算图
注：——为方案I，……为方案III，方案II各现值与方案III十分接近，图上未注出。方案I与方案II比较，IRR≈14.6%。

1. present worth (PW) (100 million yuan); 2. Scheme I favorable; 3. ___Scheme I (the scheme of developing Tianshengqiao First Stage first;) 3. ----- Scheme II (the scheme of developing Longtan first in stages.) 5. Note: ___ is Scheme I, ---- is Scheme III. The various present worth figures of Scheme II are very close to those of Scheme III. Not included in Fig. 3 are comparisons between Scheme I and Scheme II. IRR = 14.6 percent.

At present, the rate of capital return for China's electrical power industry is temporarily assumed to be 10 percent. As demonstrated in Table 5, under the discount rate conditions of 8, 10, and 12 percent, the present worth of Scheme I always remains to be the smallest. The Fig. 3 further demonstrates that when Scheme I is compared separately with Scheme II and Scheme III, the internal rate of return is 14.6 (not shown in Fig. 3 but the computation has been made;) and 12.4 percent respectively. Both are greater than 10 percent.

The results of both methods may be observed to be the same. Both indicate that Scheme I is the most beneficial. The reason is the fact that Scheme I can implement the principles discussed previously. This scheme causes the advantages of developing Tianshengqiao First and Second Stages as one group and becoming operational early to be fully materialized. At the same time, Yantan will also be operational earlier. The operation volume and the power volume before 1995 are therefore the greatest. Although during the 7th 5-year plan and the 8th 5-year plan, the capital investment for Hongshui River Project is rather large, (see Table 4), Thermal power supplement capacity, power volume, and investment are the smallest for this scheme; therefore, the total economic benefit is the best.

Through aforementioned analyses and computation of the second and the third problems, the opinions of the Hongshui Project Review Conference, called in October of last year by the National Energy Committee and the National Planning Committee, concerning the cascade development schedule are shown to be proper. The opinions are as follows:

1. Tianshengqiao Second Stage (low dam) should resume work in 1982;
2. Tianshengqiao First Stage (high dam) and Yantan Hydroelectrical Power Station should begin construction, as much as possible, during the 6th 5-year plan period;
3. For the two hydroelectrical power stations of Longtan and Datengxia, at present, it is mainly intensifying the preparation work. When will conditions be ready for the construction to begin will be determined in the course of national planning in the future.

It may be predicted that by arriving at basically uniform opinions at this conference regarding the major problems of the development policy of Hongshui River, the cascade development program, and the development schedules, there will be many positive and long range effects on the development of Hongshui River and on the resolution of the energy shortage problem of South China.

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